AVIATION SAFETY AND SECURITY PROGRAM
(AvSSP)

2.1 Aviation System Monitoring & Modeling (ASMM)

Sub-Project Plan

February 2004

Version 4.0

AVIATION SYSTEM MONITORING & MODELING SUB-PROJECT PLAN

SYSTEM SAFETY TECHNOLOGY PROJECT

AVIATION SAFETY AND SECURITY PROGRAM

SST Project
Approved

_______________________________________ __________

Brian E. Smith, Manager — Date
System Safety Technology Project

ASMM Sub-Project
Submitted

_______________________________________ __________

Irving C. Statler — Date
Aviation System Monitoring & Modeling Sub-Project Manager

ASMM SUB-PROJECT PLAN 1

LIST OF FIGURES

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ABBREVIATIONS AND ACRONYMS

AATT	Advanced Air Transportation Technology Program (includes CTAS, AvSTAR, SMA, etc)
AFA	Association of Flight Attendants
ALPA	Airline Pilots Association
AM	Accident Mitigation
AOPA	Aircraft Owners & Pilots Association
AOS	Aviation Operations Systems
APA	Allied Pilots Association
APMS	Aircraft Performance Measurement System
ARC	NASA/Ames Research Center
ASAP	
ASIST	Aviation Safety Investment Strategy Team
ASMM	Aviation System Monitoring & Modeling
ASRS	Aviation Safety Reporting System
ATA	Air Transport Association
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
AvSP	Aviation Safety Program
AvSPEC	Aviation Safety Program Executive Council
BA	British Airways
BASIS	British Airways Safety Information System
BMA	British Midland Airways
CAA	Civil Aviation Authority
CAST	Commercial Aviation Safety Team
CICT	Computing, Information, & Communications Technology Program.
CICTT	CAST/ICAO Common Taxonomy Team
CORBA	Common Object Request Broker Architecture
CVSRF	Crew Vehicle Systems Research Facility
DFRC	NASA/Dryden Flight Research Center
DLR	German Aerospace Center
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DSL	Digital Subscriber Line
ECS	Engineering Complex Systems
FAA	Federal Aviation Administration
FFC	Future Flight Central
FOQA	Flight Operational Quality Assurance
FSF	Flight Safety Foundation
FTE	Full-time Equivalent
FY	Fiscal Year
GA	General Aviation
GAIN	Global Aviation Information Network
GRC	NASA/Glenn Research Center
GSA	Government Services Administration
HAI	Helicopter Association International

IATA	International Air Transport Association
ICAC	In-Close Approach Change
ICAO	International Civil Aviation Organization
ICASS	International Confidential Aviation Safety Systems
IDEAS	International Data Exchange on Aviation Safety
IIR	Independent Internal Review
IMA	International Association of Machinists & Aerospace Workers
IRL	Implementation Readiness Level
KLM	Royal Dutch Airlines
LaRC	NASA/Langley Research Center
MIDAS	Model-Based Design, Integration, and Analysis Systems
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NBAA	National Business Aircraft Association
NAOMS	NAS Aviation Operational Monitoring System
NAR	Non-Advocate Review
NAS	National Aviation System
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Controllers Association
NIAC	NAS Information Architecture Committee
NLR	National Aerospace Laboratory (The Netherlands)
NPSS	Numerical Processing Simulation System
NRA	NASA Research Announcement
NRL	Naval Research Laboratory
NTSB	National Transportation Safety Board
OMG	Object Management Group
ONERA	Office National d'Etudes et de Recherches Aerospatiales (the French National Aerospace Research Establishment)
OSAT	Offices of Safety & Assurance Technology
PBC	Performance-Based Contract
PDARS	Performance Data Analysis and Reporting System
RTCA	Radio Technical Commission on Aeronautics
SAA	Space Act Agreement
SAAP	Single Aircraft Accident Prevention
SAE	Society of Automotive Engineers
SITA	Societe Internationale de Telecommunications Aeronautiques
SMA	Surface Movement Advisor
SST	System Safety Technology Project
SV	Synthetic Vision
SWAP	System-Wide Accident Prevention
TBS	To Be Supplied
TRACON	Terminal Radar Approach Control
TRL	Technology Readiness Level
WAP	Weather Accident Prevention
WBS	Work Breakdown Structure
XML	Extensible Markup Language

1.0 INTRODUCTION

This plan provides a description of the NASA Aviation Safety and Security Program's (AvSSP) Aviation System Monitoring and Modeling (ASMM) Sub-Project of the System Safety Technology (SST) Project. The ASMM Sub-Project focuses on the development of technologies to enable proactive management of safety-risk in the operations of the national aviation system. The purpose of this plan is to present the objectives, technical approach, resources, commercialization, and programmatic risk management for the ASMM Sub-Project.

1.1 SUB-PROJECT OVERVIEW

Background

There is a need for a comprehensive, accurate, and insightful method for monitoring the operational performance of the National Aviation System (NAS). US aviation policy makers do not currently have any reliable measures of the frequencies or the trends of aviation safety incidents. Technology developers need to know whether new equipment or procedures inserted into the aviation system are producing expected improvements and/or unwanted side effects.

The government and the world aviation community continue to routinely amass large quantities of data that could be sources of information relevant to aviation safety. Increasingly, the accumulation of these data outpaces the community's ability to put them to practical use. It is difficult to combine data related to the same subject when they come from diverse, heterogeneous sources. Often safety data cannot be retrieved after they have been put into computerized storage because of the way that the data were categorized. The ability to monitor continuously, convert the collected data into reliable information, and share that information for collaborative decision making is the basis for a proactive approach to identifying and alleviating life-threatening aviation conditions and events. Similarly, fast-time simulations provide predictions of system-wide effects of proposed interventions.

Purpose

Aviation System Monitoring and Modeling (ASMM) is one of the sub-projects of the System Safety Technology (SST) Project under the Aviation Safety and Security Program. The other projects are aimed at developing solutions to problems that have been identified as causes of past accidents. ASMM, instead, is primarily concerned with gaining insight to the health and safety of the NAS by providing technologies to facilitate efficient, comprehensive, and accurate analyses of data collected from various sources throughout the NAS during daily normal operations. As shown in Figure 1.1, fatal accidents are only a portion of the data relating to overall aviation safety. The focus of the ASMM Sub-Project is to ensure that precursors of the next accident are reliably identified, assessed, and managed.

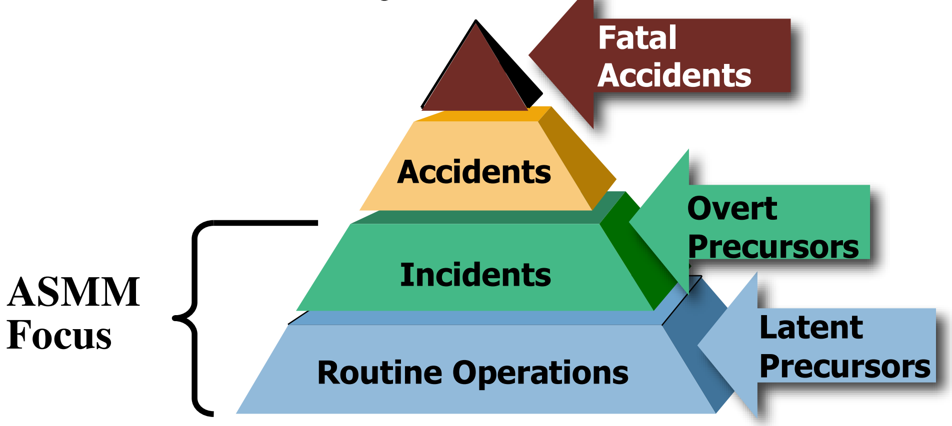


FIGURE 1.1
ASMM FOCUS ON PRECURSORS

Therefore, the aim of the ASMM sub-project is to exploit information technology resources to

¬ provide decision makers in the aviation community with regular, accurate, and insightful measures of the health, performance, and safety of the NAS, thereby enabling definition of operational trends and identification of developing conditions that could compromise NAS safety, and

¬ provide decision makers with the capabilities for reliable evaluations of the operational significance and causal factors of identified incidents or trends, thereby enabling well designed interventions, and

¬ provide technology and procedure developers with reliable predictions of the system-wide effects of the changes they are introducing into the NAS, thereby,

¬ enabling an industry-wide, and eventually worldwide, proactive approach to identifying and alleviating life-threatening conditions and events,

1.2 CUSTOMER DEFINITION AND ADVOCACY

The ASMM approach emphasizes identification of user needs up front. The users, including FAA, NASA, other government agencies, aviation industry, vendors, unions, universities and international organizations, have identified their needs through user-needs studies or focus groups and have been participating in evolving ASMM developmental efforts from the start. This will help with user acceptance and ensure a clear transition path to industry implementation.

Project Element	Government Customers	Industry Customers	Academia Customers	International Customers
Data Analysis Tools	FAA: ATS, System Safety, System Capacity, Human Factors, Flight Standards, Tech Center DOD, DOE, DOT, NTSB NASA: AATT, AvSTAR, ECS	ATA, AOPA, NBAA, Air carriers, GA and Rotorcraft operators, Data-processing vendors, aircraft manufactures Unions: ALPA, APA, AFA, IMA, NATCA	Technology developers and human factors researchers	GAIN, CAA, ICAO, IATA, NLR, ONERA, BA, KLM, BMA, ICASS, IDEAS, Euroncontrol
Intramural Monitoring	FAA: System Safety, System capacity	ATA, AOPA, NBAA, Air carriers, GA and Rotorcraft Operators Unions: ALPA, APA, AFA, IMA, NATCA		
Extramural Monitoring	FAA: System Safety	ATA, AOPA, NBAA, Air carriers, GA and Rotorcraft Operators		
Modeling & Simulations	FAA; Human Factors, Tech Center DOD, DOT, DOE NASA: AATT, AvSTAR, ECS	Air carriers, GA and Rotorcraft Operators	Technology developers and human factors researchers	NLR, ONERA, Eurocontrol

FIGURE 1.2
ASMM COLLABORATIONS/ SAFETY-RELATED CUSTOMERS

As indicated in Figure 1.2, the ASMM sub-project entails extensive interactions with stakeholder organizations to ensure that the capabilities under development are truly responsive to the needs of the aviation community. Each element in the ASMM sub-project has been coordinated and reviewed with the FAA and Industry. For those elements that have operational personnel sensitivities, additional coordination has taken place with the various relevant unions. Element activities have been designed based on lessons learned from interaction with the aviation community during the Aviation Performance Measuring System (APMS) project started in NASA by the FAA, the Aviation Safety Reporting System (ASRS) managed by NASA for the FAA, the Capacity Programs, and the Aviation Operations Systems (AOS) Project of the Computing, Information, & Communications Technology (CICT) Program.

To insure trust, integrity, and continued advocacy, regular meetings, telecons, and national workshops are conducted with target users. Formal agreements are entered into with potential users to test and evaluate new tools and concepts in the operational environment. Agreements are frequently executed with the commercial vendor selected by the customer to assist in the evolutionary development of the capabilities and in the commercialization of those that the customer finds useful. Additionally, for new task implementations, pilot trials are conducted to evaluate and test operational concepts in order to address any user issues.

2.0 GOALS, OBJECTIVES & WORK BREAKDOWN STRUCTURE

The basic ASMM concept and purpose is to support proactive management of aviation-safety risk by developing technologies that enable:

- efficient and effective feedback
    - continuously monitoring the aviation system operations
    - identifying potential safety risks
    - characterizing the frequency and severity of safety risks
    - gaining insightful understanding of the data
- reliable prediction
    - evaluating system-wide effects of alternative interventions
- easy sharing of information
    - integrating information derived from diverse, heterogeneous databases
    - collaborating on decisions and intervention strategies

2.1 GOALS

The overall goal of the ASMM sub-project is to enable and support proactive management of safety and risk in the National Aviation System (NAS). ASMM will help provide decision-makers in air carriers, air traffic management, and other air-service providers with regular, accurate, and insightful measures of the health, performance, and safety of the NAS. ASMM outputs will also provide technology and procedure developers with reliable predictions of the system-wide effects of the changes they are introducing into the aviation system. This capability will enable definition of operational and safety trends and the identification of developing conditions that could compromise NAS safety. It will also allow an industry-wide, and eventually a worldwide, proactive approach to identification and alleviation of life-threatening aviation conditions and events.

2.2 OBJECTIVES

The ASMM Objectives are to develop the technologies to:

a) identify causal factors, accident precursors, and off-nominal conditions in the aviation data,

b) provide health, performance and safety information to decision makers, and

c) ensure seamless aviation information services.

Meeting these objectives will represent qualitative measurements of the ASMM system. The goals and objectives of the each ASMM activity element are discussed in Sections 4.1.1 through 4.1.4.

The four-fold approach of the ASMM sub-project is to:

¬ Develop tools to extract and display reliable information from large databases with which experts can gain insight into the performance and safety of the NAS and can identify situations that may indicate changes to levels of safety,

¬ Develop methodologies and tools to enable efficient monitoring of the NAS by routinely processing large masses of both anecdotal and quantitative data pertaining to all aspects of the NAS,

¬ Assist and encourage stakeholders in the NAS in the use of these tools for their operational evaluation and continuous evolutionary development, and

¬ Develop fast-time simulations that enable reliable predictions of system-wide effects of proposed technological or procedural changes.

2.2.1 Definitions

Throughout this document, we use certain terms that are frequently used in the literature but with various definitions. We specify the following definitions to ensure the understanding of these terms as we use them:

θ The term "precursor" is used to mean the symptom of a systemic problem that is conducive to human error and has the potential to result in an unwanted state or accident if left unresolved. A symptom is a measurable deviation from expectations or normal standards.

θ The term "causal factors" are latent and proximate factors that include:

–Conditions *necessary* for the occurrence of a precursor

AND

–Conditions that *increase the probability* of occurrence of that precursor.

The treatment of the causal factors often entails a re-design, a new procedure, and new training.

θ Safety risk assessment is the probability of transitioning to an unwanted or anomalous state from a safe state after an incident (precursor) occurs.

Risk = P (incident) x P (consequence/incident) x P (severity/consequence)

Another consideration that is fundamental to the objectives of the ASMM sub-project is where to look for evidence of the precursors. This notion is conveyed in the Figure 2.1. ASMM is developing the capabilities to efficiently extract information from all of these data sources.

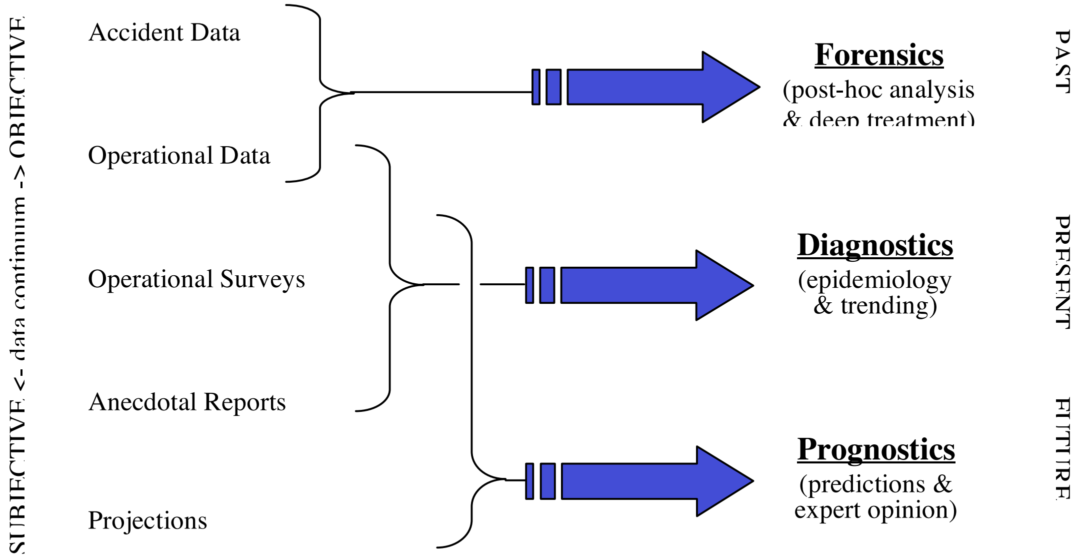


FIGURE 2.1
WHERE ARE PRECURSORS TO BE FOUND?

2.3 WORK BREAKDOWN STRUCTURE

ASMM currently consists of four elements that emphasize development and application of information technology research to capitalize on aviation data:

- Data Analysis Tools Development (ASMM WBS Element 2.1.1)
- Intramural Monitoring (ASMM WBS Element 2.1.5)
- Extramural Monitoring (ASMM WBS Element 2.1.2)
- Modeling & Simulations (ASMM WBS Element 2.1.3)

For the first two years of the AvSSP Program, ASMM also had an element 2.1.4 called *Information Sharing* that had been designed to address the need for a reliable and secure infrastructure for sharing information both intramurally and extramurally. During the re-scoping study at the end of FY'01, this element was eliminated and the activities in support of intramural and extramural monitoring were moved to those respective elements. This Sub-Project Plan for ASMM does not address *Information Sharing* per se, because all of the work completed under the *Information Sharing* element during its two years was entirely related to the other elements of ASMM. Therefore, the previous and future activities relevant to information sharing are described within the supported elements.

ASMM will merge these activity elements and their products into a system-wide framework enabling aviation safety-risk management by aviation policy makers whether they are in government or industry, while respecting the proprietary rights to some sources of data and sensitivities to potential misuse should they be released outside the owning organization.

3.0 PROJECT AUTHORITY/MANAGEMENT

3.1 ORGANIZATION

The Aviation Safety and Security Program (AvSSP) Level 1 Director is George Finelli. Brian E. Smith is the Manager of the System Safety Technology Project at the Ames Research Center (ARC). The Executive Board of the Aero-Space Technology Enterprise is responsible for the oversight of the project. The project authority is derived from the approval of the AvSSP Program from PMC. Any changes to that approval must go through the AvSSP Program Office to the Enterprise Executive Board for final approval. As shown in Figure 3.0, the ASMM sub-project is one of the projects under System Safety Technology of the Aviation Safety and Security Program. Lead program personnel for ASMM reside at ARC. The ASMM Sub-Project Manager is Irving C. Statler. The ASMM Element managers are as follows:

- Irving C. Statler and Michael G. Shafto (WBS 2.1.1: Data Analysis Tools)
- Thomas R. Chidester (WBS 2.1.5: Intramural Monitoring)
- Linda J. Connell and Mary M. Connors (WBS 2.1.2: Extramural Monitoring)
- Irving C. Statler (WBS 2.1.3, Modeling & Simulations)

3.2 RESPONSIBILITIES

3.2.1 <u>ASMM sub-project Managers</u>

The ASMM Sub-Project Manager is responsible for implementation of this AvSP project with full authority to manage the project within the defined objectives, technical scope, schedules, and resources. The ASMM Sub-Project Manager reports to the System Safety Technology Manager. Specific responsibilities include:

- Defining and implementing the technical project within the technical, cost, and schedule constraints established by the program plan
- Executing project control, with authority to reprogram element resources across Centers as necessary to address technical, schedule, and resource priorities, but not to exceed the smaller of $750K or 15% of a given year's budget and providing that Project or Program level milestones are not adversely affected.
- Management of all resources (facilities, workforce, and funding) required to meet the milestones identified for the project
- Providing advice and recommendations for changes to the Program Plan to the AvSP Program Director, and implementing changes upon approval
- Preparing periodic element reports, annual AvSP Office reviews, and other reviews as required
- Acting as primary interface with outside customers and partners to ensure effective technical direction and implementation of the project elements
- Representing technical plans, objectives, approaches, and progress to NASA/Headquarters management, other government agencies, interagency coordinating committees, technology committees, and working and steering groups
- Maintaining cognizance of related program activities (including NASA base and focused programs, as well as FAA, industry, and international efforts) and periodically reporting on their status and relevance

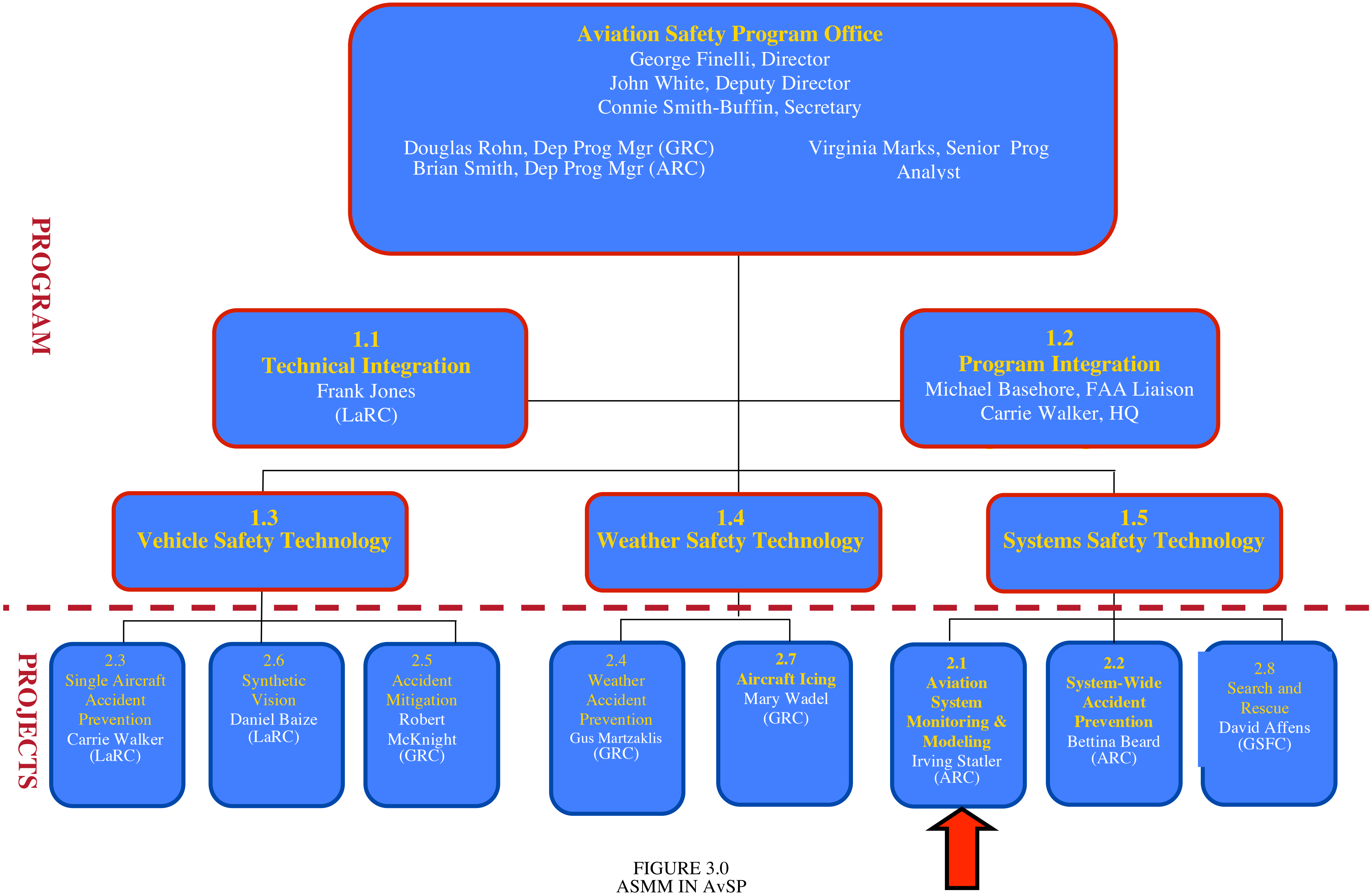


FIGURE 3.0
ASMM IN AvSP

3.2.2 ASMM Element Managers

The ASMM Element Managers are responsible for implementing the ASMM Sub-Project within each ASMM element with full authority to manage within the defined objectives, technical scope, schedules, and resources. Element Managers report to the ASMM Sub-Project Manager. Specific responsibilities include:

- Defining and implementing technical activities within the technical, cost, and schedule constraints established by this plan and their respective element plans
- Authority to reprogram element funding resources up to 15% of guideline across sub-element activities within their element as necessary, to address technical, schedule, and resource metrics.
- Ensuring technical integration is implemented across all sub- elements
- Providing advice and recommendations for changes to the respective element plans to the ASMM Element Manager, and implementing changes upon approval
- Preparing monthly project reports, technical highlights, annual ASMM Sub-Project reviews, and other reviews as required
- Representing technical plans, objectives, approaches, and progress to AvSP management, other government agencies, interagency coordinating committees, technology committees, and working and steering groups
- Maintaining cognizance of related program activities (including NASA base and focused programs, as well as FAA, industry, and international efforts) and periodically reporting on their status and relevance.
- Ensuring that a Risk Management Process is in place for the element

3.3 CONTROLS

The Sub-Project Manager exercises control through the Configuration Management process, which records changes and maintains the current status of programmatic baseline documentation. Changes to the controlled documents will follow a configuration management process to assess the impacts and approve proposed changes, notify all affected parties, and verify/update designated documents. The Sub-Project Plan will be updated as required to maintain compatibility between the plan and changes in resource availability. A monthly report by the Sub-Project Manager to the Project and Program Managers will be developed. This report is an integrated assessment of technical, cost, and schedule progress versus plan and will contain significant technical highlights. Issues and/or concerns (including potential impact and proposed action) and any major interactions with partners will be identified. Additionally, the Sub-Project Manager will support Center Program Management Council meetings as required by the Program Manager or Center management.

3.4 DATA MANAGEMENT

The Sub-Project Manager is responsible for the protection of the information generated within the Sub-Project and will take appropriate actions to protect it depending on its sensitivity.

3.4 LOGISTICS

This technology development Project does not provide mission, flight, or systems hardware intended for long-duration use and as such is exempt from logistics management.

THIS PROJECT IS IN FULL COMPLIANCE WITH NPG 7120.5B.

4.0 TECHNICAL APPROACH

4.1 SUB-PROJECT REQUIREMENTS

The work of ASMM exploits information technology to address the problem of monitoring the aviation system by

- Developing the tools and methodologies for a strategy of dual complementary capabilities of "bottom-up" and "top-down" monitoring to obtain feedback from aviation data,
- Developing the infrastructure capabilities for sharing information specific to the developed tools and methodologies, and
- Utilizing the collected textual and quantitative data to support the development and validation of system-wide models and simulations for predictions and safety risk assessments.

These goals will be realized by the work to be accomplished under the four elements of the ASMM WBS; 2.1.1: Data Analysis Tools Development, 2.1.5: Intramural Monitoring, 2.1.2: Extramural Monitoring, and 2.1.3: Modeling and Simulations as shown in Figure 4.1 (A) below.

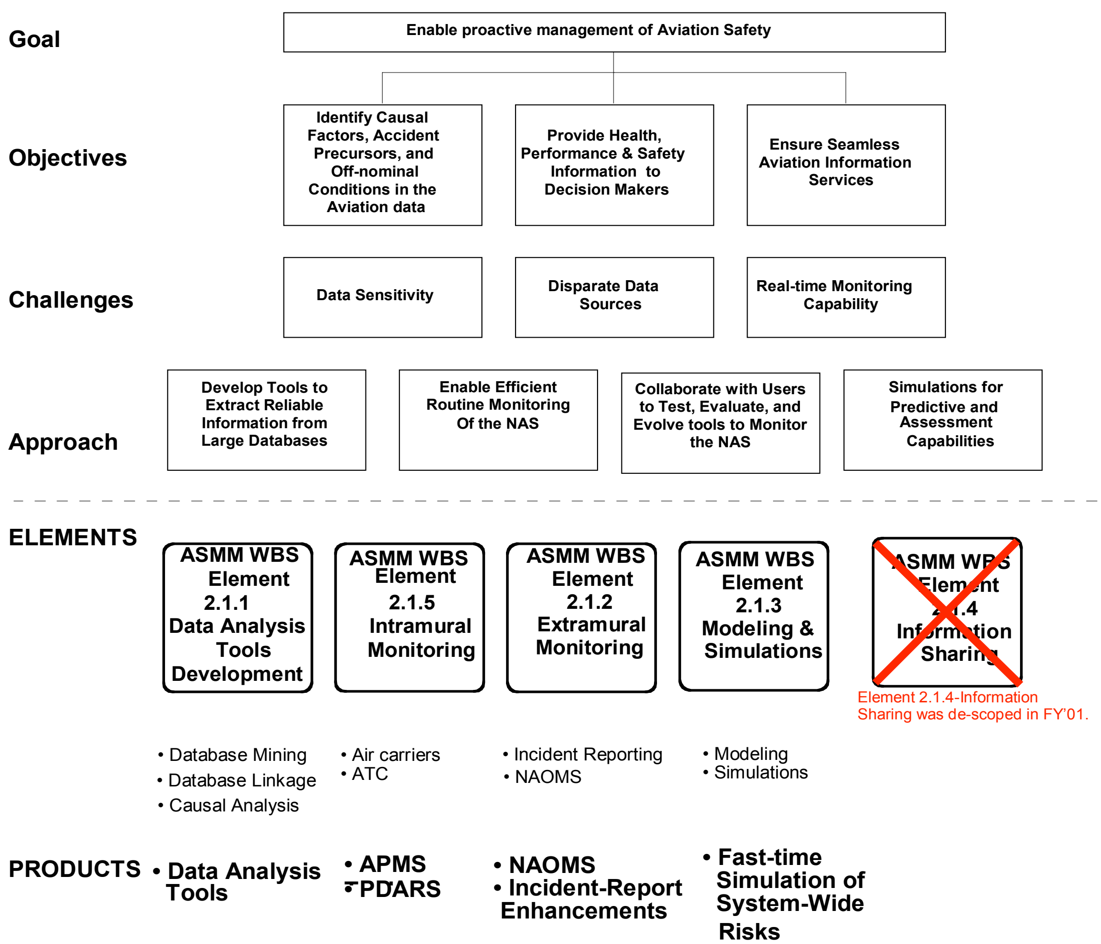


FIGURE 4.1(A)
ASMM SUB-PROJECT OVERVIEW

The ASMM sub-project is developing the technologies to enable the industry to move from solely reactive management to proactive management of safety risk, i.e., minimize risk by learning continuously from normal operational experience, and identifying and responding to precursor events. The cyclic concept of proactive management of safety risk, illustrated in Figure 4.1(B), entails the following four primary steps that relate directly to the concept as portrayed in Figure 4.4:

- IDENTIFYING – monitoring the system performance continuously and comparing with established standards to identify potential risks.
- EVALUATING - diagnosing the causal factors, estimating the likelihood of future occurrences, and assessing the severity and possible impacts
- FORMULATING – proposing changes, assessing the safety risk, estimating benefits and costs, and developing a strategy for implementing a change
- IMPLEMENTING – implementing on a small scale, evaluating the intervention, refining, establishing performance standards, and monitoring to assess the efficacy of the intervention and to identify unwanted side effects.

Throughout this process, decisions must be made by aviation-domain experts in the industry, who set the performance standards, gain insight from monitoring, propose the changes, and develop the intervention strategies. ASMM cannot replace this expertise with automation. However, ASMM can provide the methodologies, the computational tools, and the infrastructure to assist the experts in making the best possible decisions.

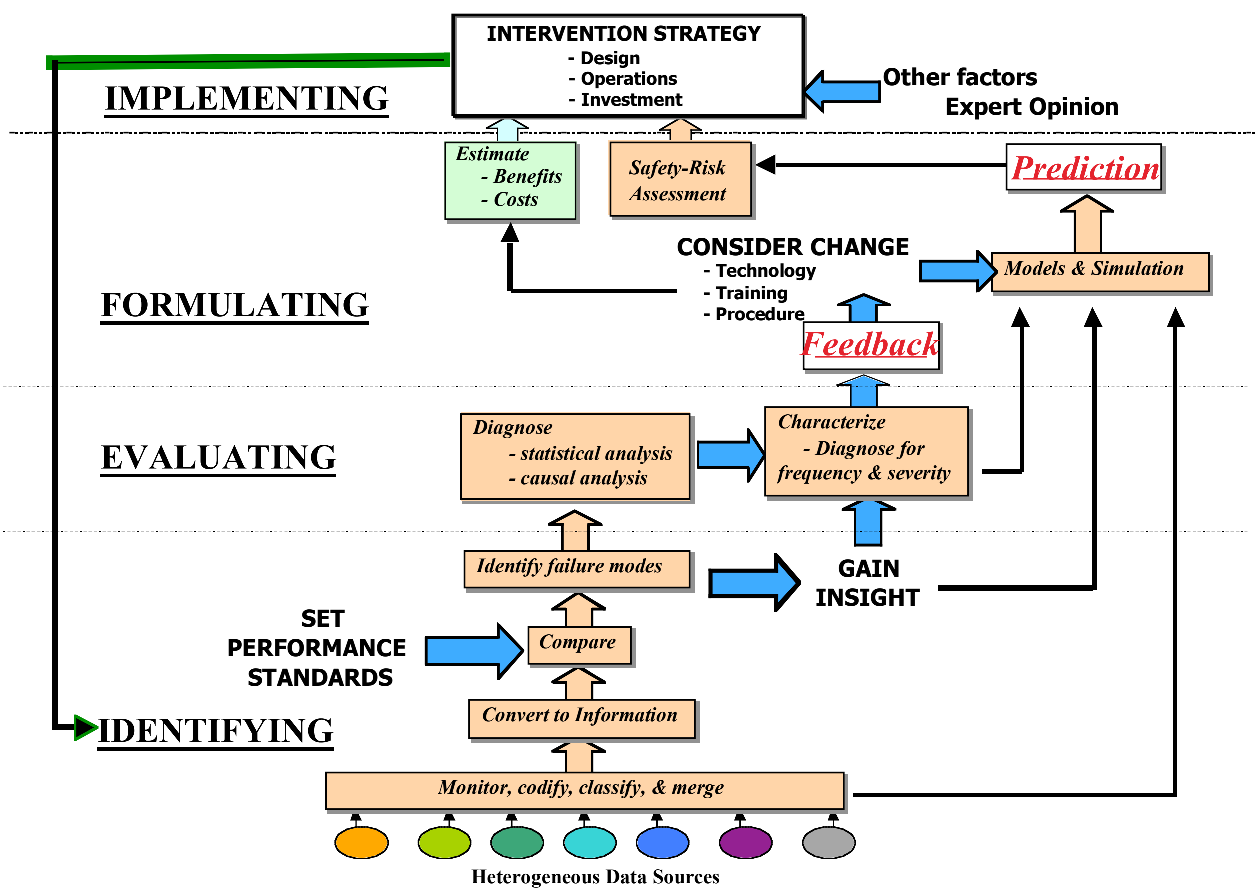


FIGURE 4.1(B)
ASMM CYCLIC CONCEPT OF PROACTIVE MANAGEMENT OF RISK

The *Data Analysis Tools Development* element provides for the research that will result in software to perform tasks that presently can only be performed by experts with much time and effort. We will develop capabilities to process textual and numeric aviation data, and recognize relevant information in diverse databases, including those derived from the activities under *Intramural* and *Extramural Monitoring*. We will develop tools to convert these data into displays of meaningful information to help analysts achieve the insight needed to understand the circumstances and propose mitigating actions.

The *Modeling and Simulations* element of ASMM addresses the need to support predictions and safety risk assessments by developing and validating system-wide models and simulations. The data collected from all of the activities under *Intramural* and *Extramural Monitoring* will be used to support the development and validation of models of the National Aviation System.

Our approach to monitoring entails a dual strategy of complementary monitoring capabilities for feedback. Two distinct, independent but complementary aviation-monitoring capabilities will be created.

The *Intramural Monitoring* element is intended to provide the air-service operators with the tools needed to monitor their own performance and safety continuously, effectively, and economically within their own organizations.

The *Extramural Monitoring* element complements *Intramural Monitoring* and is a comprehensive system-wide survey mechanism for monitoring the performance and safety of the overall National Aviation System and for detecting and evaluating the effects of new technologies as they are inserted into the system.

While helping air services organizations build their intramural capability for safety monitoring and for establishing a potential database for the Aviation Safety Program, we will develop a comprehensive survey system for monitoring safety performance on a national scale. The concepts and capabilities of the two approaches (i.e., top-down extramural monitoring and bottom-up intramural monitoring) will evolve independently in parallel. However, information derived from each will complement the other elements of ASMM in the process of identifying precursors, monitoring the effects of changes, and developing predictive capability.

The four sub-elements of ASMM are interdependent and interrelated. They have been planned and are being worked in concert as evidenced in the ASMM sub-project and Element Milestones shown in Figure 4.1 (C), in the Element Roadmaps shown in Figures 4.1 (D) – (G), and in the descriptions of the Elements that follow in Sections 4.1.1 through 4.1.4.

Figure 4.1(C) shows the ASMM sub-project and Elements Milestones for each year of the project. The ASMM sub-project milestones are shown with triangles and the ASMM Element milestones are shown with diamonds for each of four sub-elements. Completed milestones are solid colors. Figures 4.1(D) through 4.1(G) show the corresponding underlying roadmaps for each of the four ASMM elements. The descriptions of the indicated milestones and their exit criteria are presented in Tables 4.1 (A) through 4.1 (E).

All elements of the ASMM sub-project are worked in close collaboration with industry to address continuously the challenges of the sensitivity to potential misuse of data, integration of information from disparate data sources, and the pilots' concerns related to real-time monitoring of their performance. These hurdles are common and controlling to a wide range of similar problems in other industries. ASMM team members are part of national and international aviation activities that are addressing these particular problems faced in data management. As these data-management hurdles are resolved, they will also minimize key hurdles in system-wide monitoring of aviation safety information. This will simplify element implementations for key activities such as APMS, PDARS, and NAOMS.

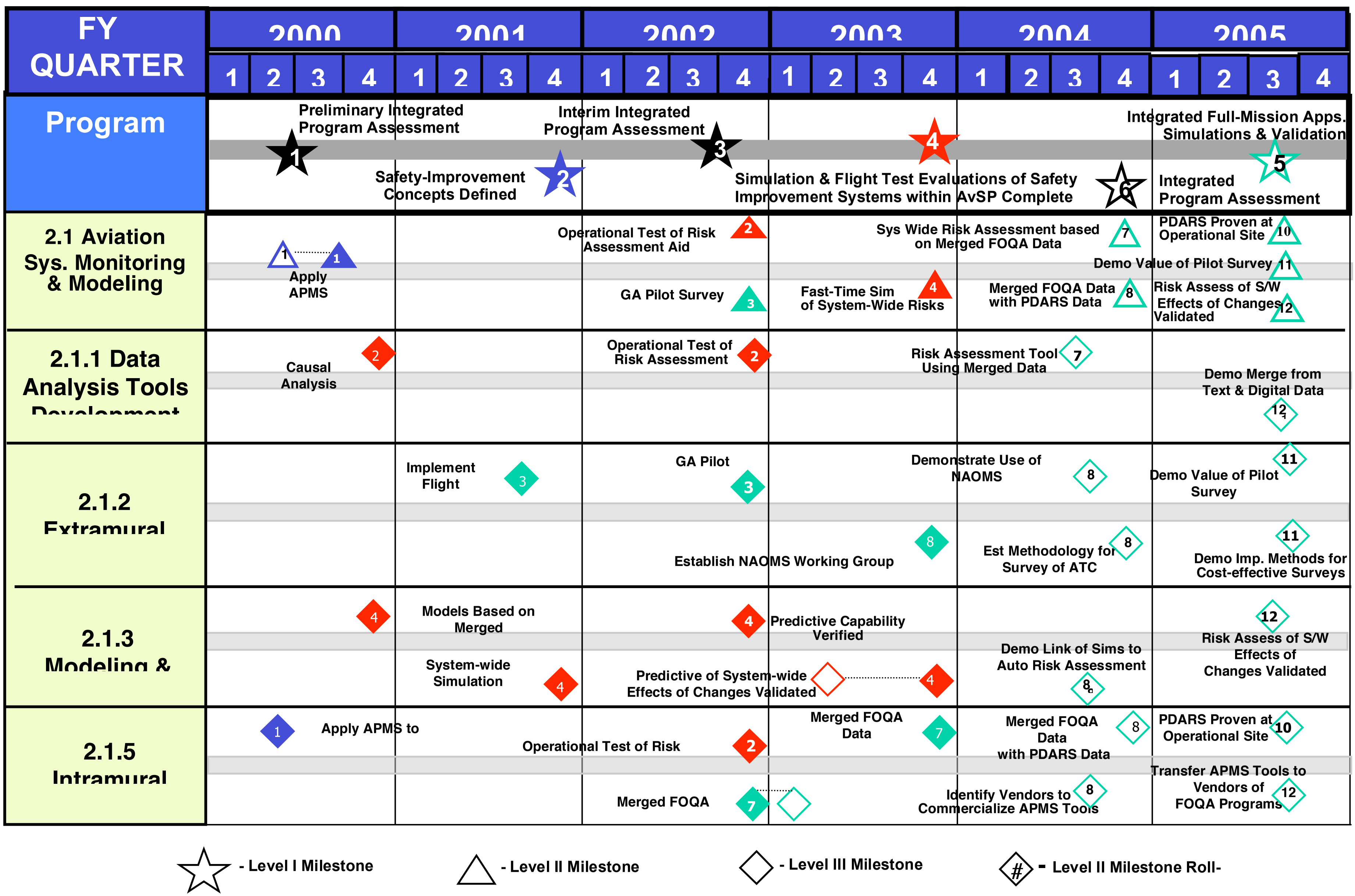


FIGURE 4.1 (C)
AvSP PROGRAM & ASMM SUB-PROJECT& ELEMENT MILESTONES

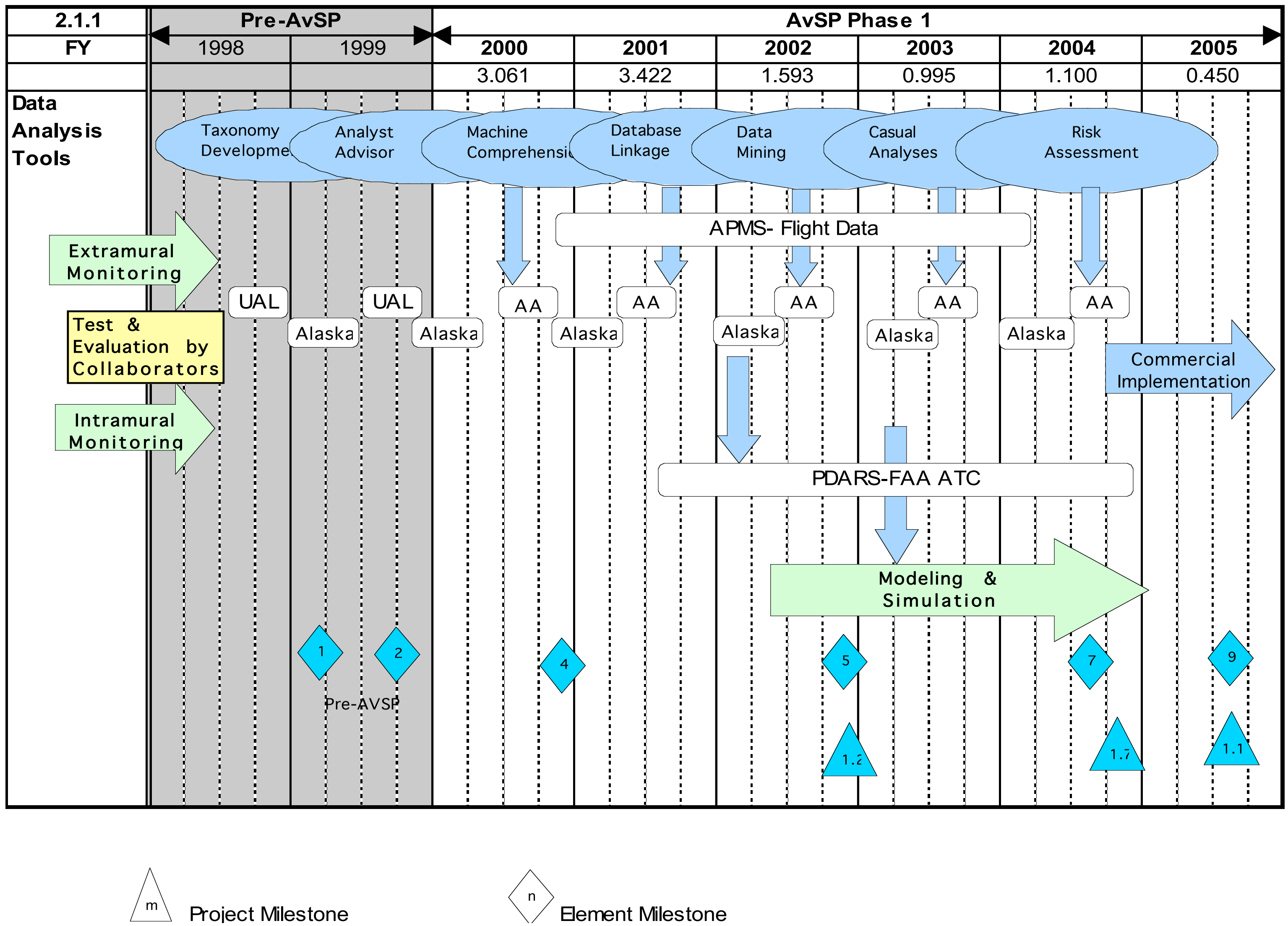


FIGURE 4.1 (D)
MILESTONES FOR
ASMM WBS 2.1.1, DATA ANALYSIS TOOLS DEVELOPMENT

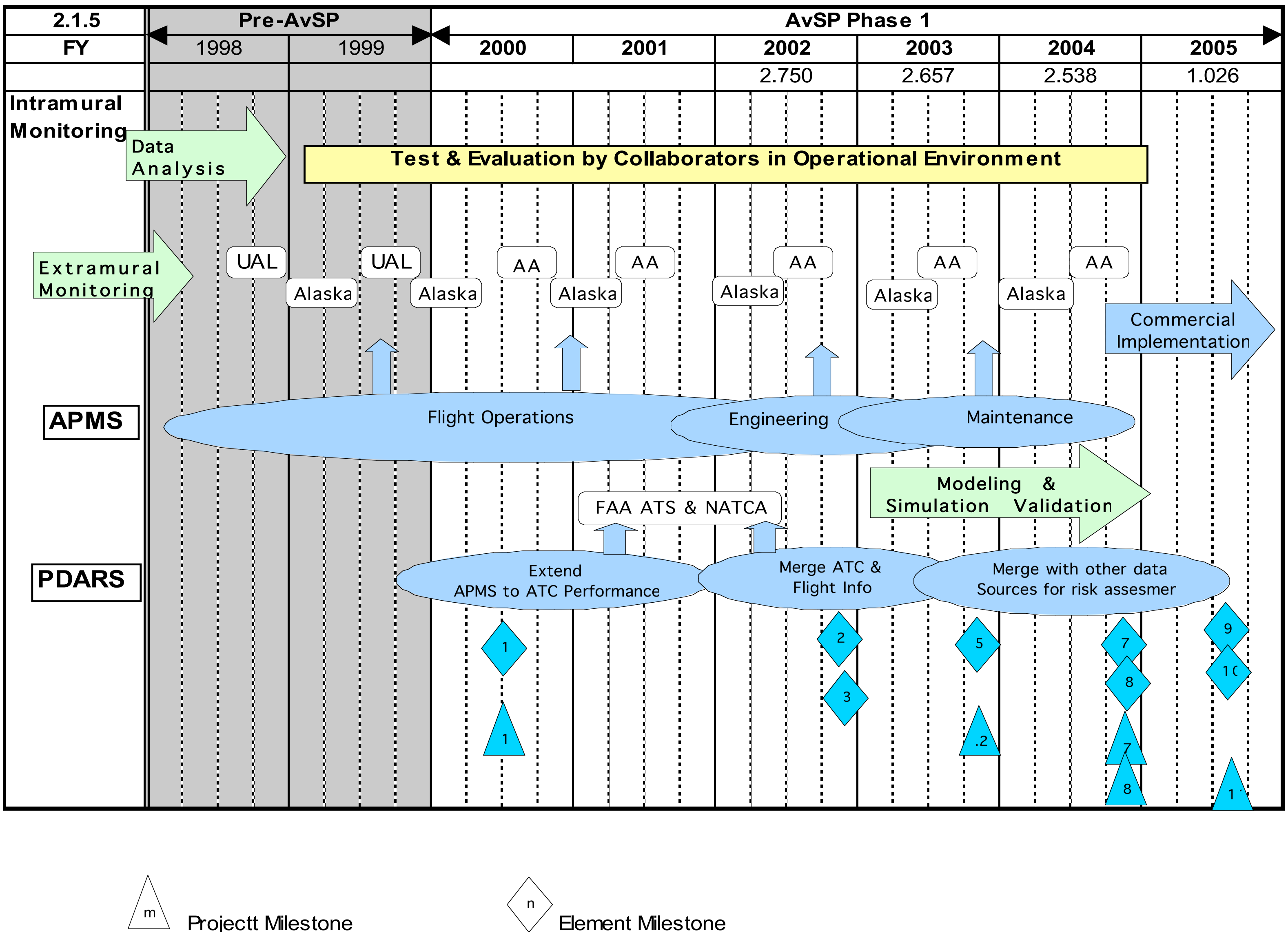


FIGURE 4.1(E)
MILESTONES FOR
ASMM WBS 2.1.5, INTRAMURAL MONITORING

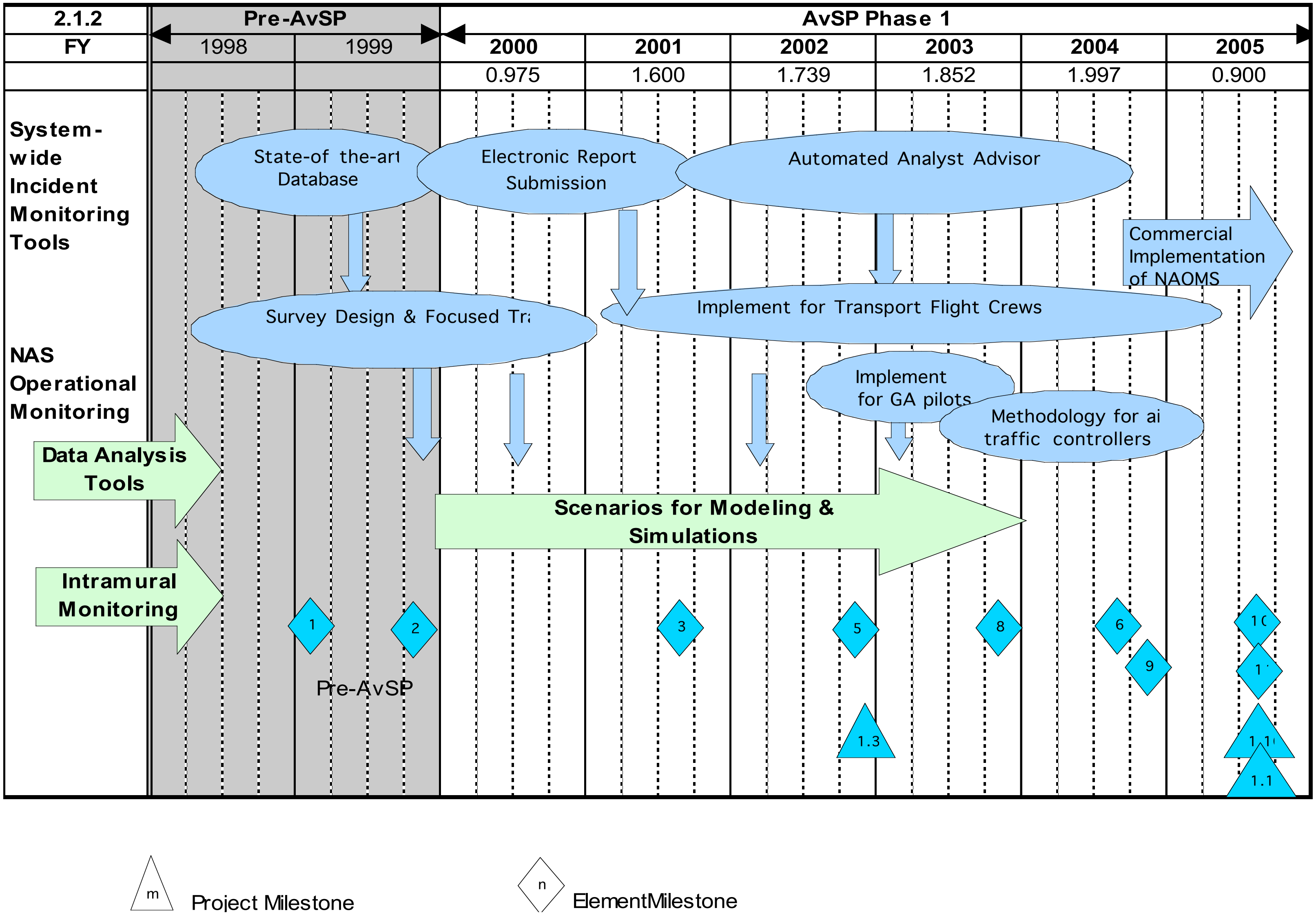


FIGURE 4.1(F)
MILESTONES FOR
ASMM WBS 2.1.2, EXTRAMURAL MONITORING

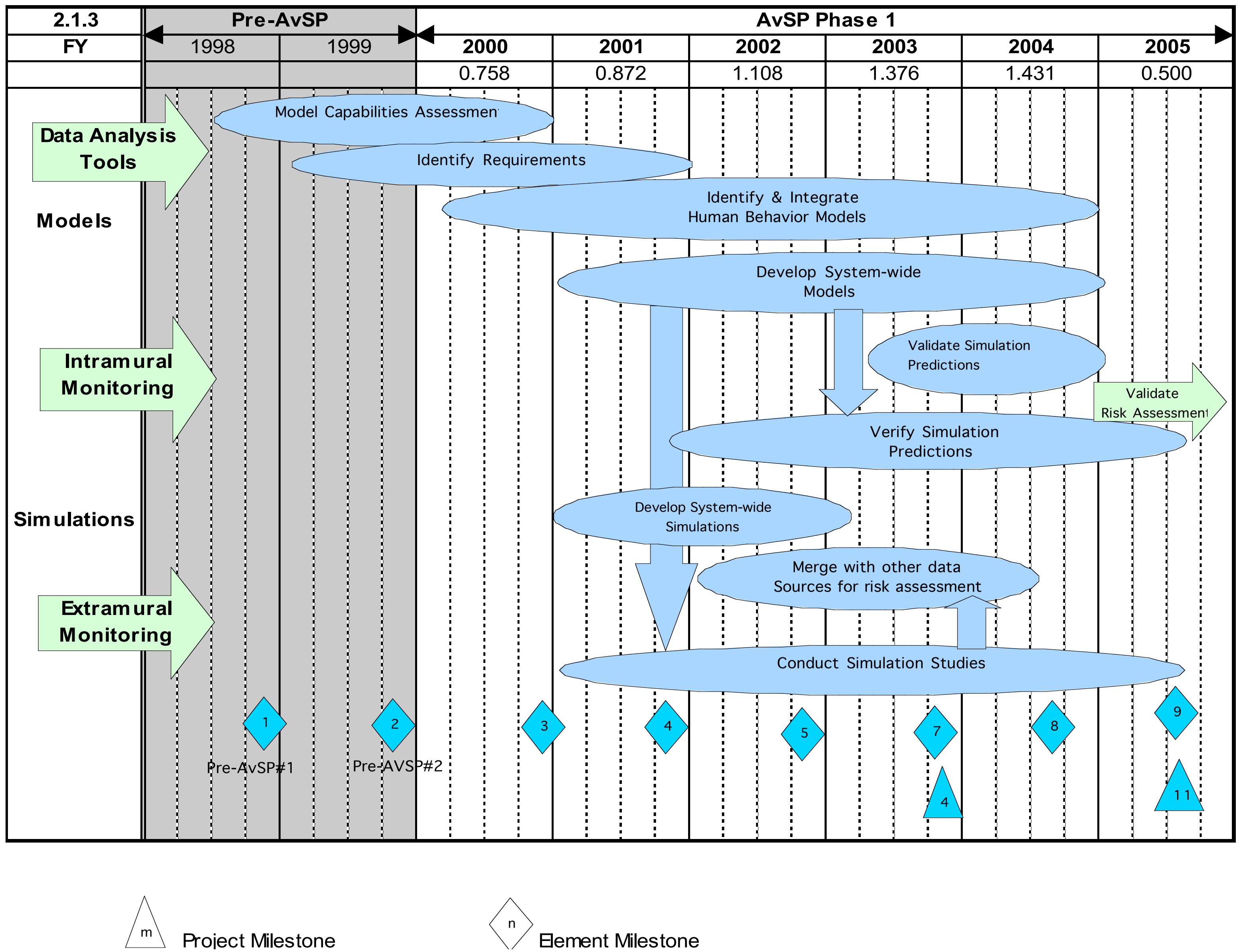


FIGURE 4.1(G)
MILESTONES FOR
ASMM WBS 2.1.3, MODELING & SIMULATION

The ASMM sub-project milestones have performance metrics that specify Technology Readiness Level (TRL) as part of the exit criteria. Figure 4.1(I) below shows the NASA Technology Readiness Levels. Another part of the exit criteria is a validation of project objectives and requirements. TRL and Implementation Readiness Level (IRL) vary according to type of product and the degree to which research is developed in conjunction with industry partners. Industry participation will determine the level of technology development. Desired implementation level of the product will depend on many scheduling, cost, political, and management factors.

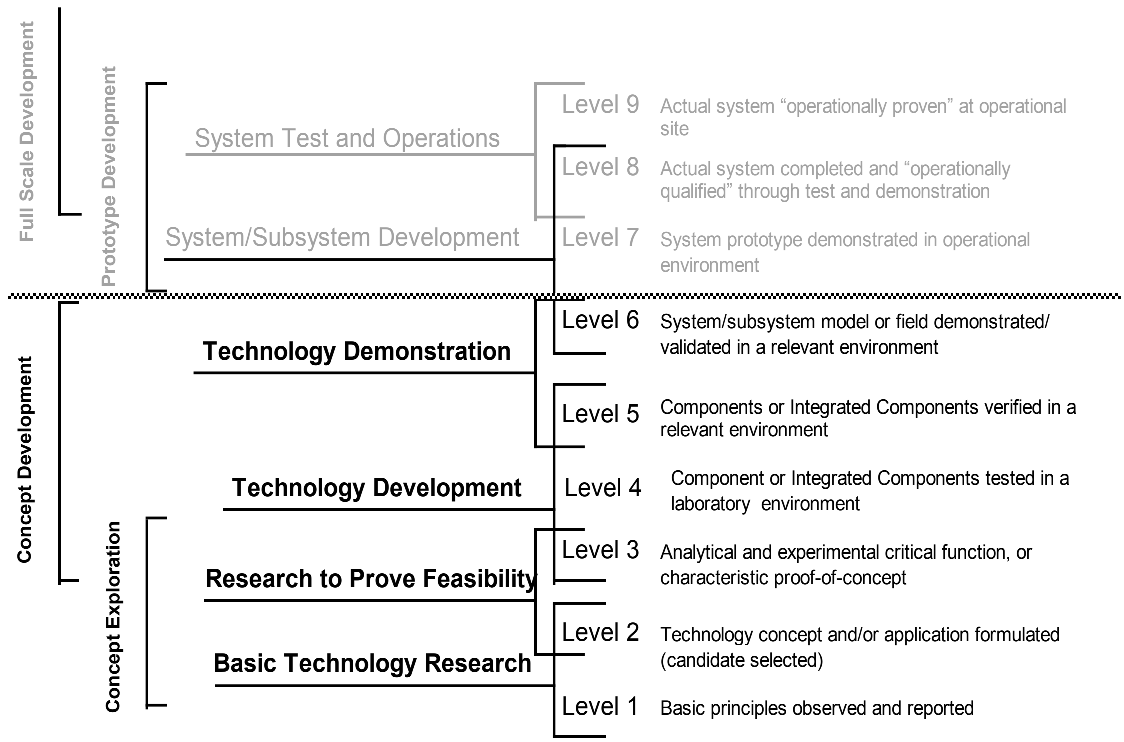


FIGURE 4.1(I)
NASA TECHNOLOGY READINESS LEVELS

Implementation of ASMM products differs significantly from typical engineering products because they are seldom defined in terms of certification criteria. The definitions shown in Figure 4.1(J) are meaningful IRL levels to assign to the ASMM milestones. These nine levels approximately correspond to the definitions of IRL established for the AvSP program.

IRL

- **9** **Operation of Certified System** - Recommendations, guidelines, technology concept, etc. required and evaluated by government regulation
- **8** **Certification Approved** - Recommendations, guidelines, technology concept required by government regulation
- **7** **Certification Standard Established** - Recommendations, guidelines, technology concept incorporated into industry and/or government advisory document
- **6** **Draft Certification Standard Developed** - Standards incorporating recommendations, guidelines or technology concept drafted into industry/or government advisory document
- **5** **RTCA/SAE or Equivalent Convened** - Presented to Industry group for consideration in standards industry implementation
- **4** **Application for Certification** - Results/products publicly presented and available for industry implementation
- **3** **Commercial Product Development Initiated** - Product ready for hand off for commercial or customer refinement
- **2** **Industry R&D Funding Committed** - Industry partner has committed funds and/or staffing resources to research
- **1** **Technology Transfer Initiated** - Results presented to industry and research partners

FIGURE 4.1(J)
ASMM IMPLEMENTATION READINESS LEVELS

Table 4.1 (A) below presents the ASMM sub-project milestones and exit criteria. These milestones roll up into AVSP Program milestones as shown in the right-most column. Tables 4.1(B)–(E) presents the ASMM Element Milestones. Program-wide technology readiness levels are shown in Tables 4.1(A) through 4.1(E).

Sections 4.1.1 through 4.1.4 define the goals, objectives, approach & milestones/TRLs for each of the four ASMM WBS Elements.

TABLE 4.1 (A)
SUB-PROJECT MILESTONE CHART
2.1 ASMM SUB-PROJECT

No.	Milestones	Exit criteria	TRL/ IRL	Date Mo/Yr	AvSP Roll-up (Mo/Yr) PRODUCT
2.1/1	**Apply Aircraft Performance Monitoring System (APMS) to Air Traffic Control (ATC):** Demonstrate application of APMS concepts and methodologies to ATC for performance monitoring.	Acceptance by the ATC community and extension to other sectors of national ATC. At least 6 facilities are actively participating in evaluation, and plans for nationalization are made.	4/1	04/00 Comp Apr 00	#2 (09/01) PDARS TOOLS
2.1/2	**Operational Test of Risk Assessment Aid:** Demonstrate, in operational environment, tools for merging heterogeneous databases to aid causal analysis and risk assessment	User concurrence on the potential for reliable and valuable automated assistance for risk assessment. At least two air service providers are providing data for developing	5/3	09/02 Comp Sep 02	#4 (03/03) APMS TOOLS
2.1/3	**GA Pilot Survey:** National Aviation System Aviation Operational Monitoring System (NAOMS) adds the GA pilot community to the survey system.	Field trials completed and GA survey launched with at least 800 interviews completed.	3/1	09/02 Comp Sep 02	#5 (06/04) NAOMS
2.1/4	**Fast-Time Simulation of System-Wide Risks:** Predictions of system-wide effects using the linked human performance/air traffic models are validated against data collected on in-close approach maneuvers to LAX. Validation based on aircraft response to request, aircraft performance to threshold, and flight crew procedures.	A measure of the predictive accuracy (i.e., correlation between statistics produced by simulation and those obtained from APMS, PDARS, and NAOMS) of 0.60 or better will be calculated.	3/1	09/03 Comp Sep 03	#4 (04/03) FAST-TIME SIM. OF SYS-WIDE RISKS
2.1/5	**Demonstrate Survey of Full NAS**: The NAOMS is incorporating inputs from the air-carrier, commercial flight crew, air-traffic-control, cabin-crew, mechanics/technicians, corporate, and GA communities routinely.	Continued positive response from all of the solicited communities. At least 60% interview completion rate.	6/3	06/05	#5 (06/05)
2.1/6	**Transfer of Aviation ExtraNet to Industry**	Aviation ExtraNet core backbone links and services transferred to third parties. Middleware services validated and maintained by third parties. End user access to top 30 US airports, real-time access to FAA centers, terminal and surface systems data, and backbone access to US airline extranets.	6/3	03/04	#5 (06/05) AVIATION DATA SHARING TOOLS & MIDDLEWARE
2.1/7	**System-wide Risk Assessment based on Merged FOQA Data:** Demonstrate value to system-wide risk assessment of basing analysis on merged FOQA data from a major portion of the NAS user community.	Two air carriers are providing data for merging into a common database. Subject-matter experts accept and use indications of system-wide safety issues from analyses of the database.	3/1	09/04	#5 (06/05) APMS TOOLS

2.1/8	**Merge FOQA Data with Performance Data Analysis and Reporting System (PDARS) Data:** Demonstrate the value to system-wide safety-risk assessment of merging FOQA data with PDARS data from the ATC community.	Two air carriers are providing data for merging with PDARS data from at least 6 ATC sites. Subject-mater experts accept and use the indications of system-wide issues related to safety from analysis of the database.	6/3	09/04	#5 (06/05) APMS & PDARS TOOLS
2.1/9	**Merge FOQA Data with Models & Simulations:** Demo use of FOQA data to enhance, verify, and validate system models and simulations.	Subject-matter experts use capability to predict system-wide effects. At least 2 major air carriers are using simulations to aid evaluations of proposed interventions	6/3	06/05	#5 (06/05) FAST-TIME SIM OF SYS-WIDE RISKS
2.1/10	**PDARS Operationally Proven at Operational Site**: Operational value of PDARS proven by its daily use at ATC facilities.	Software and network equipment transferred to FAA ATC to continue operation with all developed PDARS tools. The facilities in at least 3 of the 9 ATC regions are networked on PDARS.	6/3	06/05	#5 (06/05) PDARS TOOLS
2.1/11	**Demonstrate Value of Pilot Survey:** Results of surveys of carrier and GA pilots are statistically analyzed to identify operational issues.	Examples of operationally significant information derived from the NAOMS surveys of the air carrier and the GA pilots have been presented. Subject matter experts accept and agree with at least 75% of the issues identified.	6/1	06/05	#5 (06/05) NAOMS
2.1/12	**Risk Assessment of System-wide Effects of Changes Validated:** Analytical risk assessment tools are linked to fast-time simulations for the scenarios of "In-close Approach Changes". . Risk assessments are made for a range of a/c mixes, weather, and controller request timing. Validation of the risk projections and causal factors are based on correlations with data collected by APMS, PDARS, and NAOMS	The fully linked human performance/air traffic simulation and the risk analysis system are validated for the In-close Approach Change scenario against data collected by APMS, PDARS, and NAOMS. Risk assessments are made for a range of a/c mixes, weather, and controller request timing. Subject matter experts agree with predicted assessments of risk in at least 75% of the situations modeled.	6/1	06/05	#5 (06/05) PROTOTYPE SYS-WIDE RISK ASSESSMENT

Note: Milestone 2.1/6 Transfer of Aviation ExtraNet to Industry was deleted with the de-scope of the Information Sharing Element in FY'01. Milestones 2.1/5 Demo Survey of Full NAS and 2.1/9 Merge FOQA Data with Models & Simulations were deleted due to inadequate funds.

TABLE 4.1 (B)
ELEMENT MILESTONE CHART -
2.1.1 DATA-ANALYSIS TOOLS DEVELOPMENT

No.	Title/Description	Exit Criteria	TRL/ IRL	Date Mo/Yr	Level II Roll-up (FY Quarter) PRODUCT
2.1.1/1 Pre-AvSP	**Taxonomy Workshop:** Host first international workshop on "bridging" taxonomy	International participation and acceptance of need	7/3	12/998 Comp Dec 98	2.1/2 (06/02)
2.1.1/2 Pre-AvSP	**First-generation Causal Database:** Create first-generation causal database using advanced coding taxonomies & processes	Demonstration of improved access for human factors research and causal analysis	6/3	09/99 Comp Sep 99	2.1/2 (09/02) ASRS TOOLS
2.1.1/3	**APMS for ATC:** Demonstrate a performance monitoring system for ATC based on APMS tested in a limited portion of the ATC community.	Acceptance by the ATC community and extensions to other sectors of the national ATC. At least 6 facilities are actively participating in evaluation, and plans for nationalization are made.	4/1	2/00 Comp Apr 00	2.1/2 (09/02) APMS TOOLS
2.1.1/4	**Causal Analysis of Incidents:** Demonstrate potential capability for causal analysis of incidents from flight data	Subject-matter experts agree to the potential value of automated assistance for analyzing incidents. At least 2 air carriers providing data to develop causal analysis capabilities	3/3	09/00 Comp Sep 00	2.1/2 (09/02) APMS TOOLS
2.1.1/5	**Operational Test of Risk Assessment:** Demonstrate causal analysis and risk-assessment tools at Alaska, & TWA LLC airlines with automated linkage of heterogeneous safety-data sources.	User concurrence on the potential for reliable and valuable automated assistance for risk assessment. At least 2 air services providers are providing data for developing risk assessment capabilities	5/3	09/02 Comp Sep 02	2.1/2 (09/02) APMS, PDARS, DATA ANALYSIS, ET AL TOOLS
2.1.1/6	**APMS for Corporate A/C:** Demonstrate first builds of APMS tools for corporate aircraft incorporating guided exploration of flight-recorded data.	Acceptance of the concepts of APMS by the corporate community. At least 2 corporate operators are providing data for operational analysis.	5/3	01/03	2.1/7 09/04 APMS TOOLS
2.1.1/7	**Risk Assessment Tool using Merged Data:** Demonstrate an automated, reliable capability to assist decision-makers in assessing risk from a system-wide perspective.	Acceptance and use by subject-matter experts of the capability in the process of deciding on mitigating action. Two major air services providers are using tools to aid their safety-risk assessment.	5/3	06/04	2.1.7 (09/04) APMS TOOLS
2.1.1/8	**APMS for GA:** Demonstrate the potential applicability of APMS to GA.	Participation by the GA community in developing, adapting, and evolving APMS-like tools. At least, 2 major GA Leasers are providing data for operational analysis.	4/3	03/04	2.1/7 09/04 APMS TOOLS

2.1.1/9	**Merge FOQA Data with Models & Simulations:** Demonstrate use of FOQA data to enhance, verify, and validate system models and simulations.	Subject-matter experts accept and use capability to predict system-wide effects. At least 2 major air carriers are using simulations to aid evaluations of proposed interventions.	6/3	09/04	2.1/9 03/05 APMS TOOLS
2.1.1/10	**Demonstrate Merging of Information from Textual and Digital Data Sources:** Demonstrate an automated capability to merge relevant information from free-text reports and flight-recorded data.	Subject-matter experts accept and use the capability to assist in gaining insight into system events. Two major air carriers have agreed to rest and evaluate the capability.	5/3	06/05	2.1/12 (06/05) APMS TOOLS

NOTE: Milestones 2.1.1/3, 2.1.1/6, 2.1.1/8, and 2.1.1/9 were deleted from this activity with the re-structuring in FY'01 and have been assigned to element 2.1.5 Intramural Monitoring since FY'02.

TABLE 4.1 (C)
ELEMENT MILESTONE CHART -
2.1.5 INTRAMURAL MONITORING

No.	Title/Description	Exit Criteria	TRL/ IRL	Date (Mo/Yr)	Level II Roll-up (FY Quarter) PRODUCT
2.1.5/1	**Apply APMS to ATC**: Demonstrate application of APMS concepts & methodologies to ATC for performance monitoring.	Acceptance by the ATC community and extension to other sectors of national ATC. At least 6 facilities are actively participating in evaluation, and plans for nationalization are made.	4/1	03/00 Comp Apr 00	2.1/1 (03/00) PDARS TOOLS
2.1.5/2	**Operational Test of Risk Assessment:** Demonstrate, in operational environment, tools for merging heterogeneous databases to aid causal analysis and risk assessment.	User concurrence on the potential for reliable and valuable automated assistance for risk assessment. Two air services providers are providing data for developing risk assessment capabilities	5/3	09/02 Comp Sep 02	2.1.2 (06/02) APMS TOOLS
2.1.5/3	**Merged FOQA Data:** Demonstrate the ability and potential value to system-wide safety-risk assessment of merging de-identified FOQA data.	Two major air carriers are providing FOQA data for merging into a common database. Subject-matter experts agree with initial indications of system-wide issues related to safety.	3/1	09/02 Comp Sep 02	2.1.7 (06/04) 2.1.8 (06/05 2.1.9 (06/05)) APMS TOOLS
2.1.5/4	**APMS for Corporate A/C:** Demonstrate first builds of APMS tools for corporate aircraft incorporating guided exploration of flight-recorded data.	Acceptance of the concepts of APMS by the corporate community. At least 2 corporate operators are providing data for operational analysis.	5/3	03/03	2.1/7 09/04 APMS TOOLS
2.1.5/5	**Merged FOQA Data from Multiple Air Carriers**: Demonstrate the ability and potential value to system-wide safety-risk assessment of merging de-identified FOQA data from multiple air carriers.	Two major air carriers are providing FOQA data for merging into a common database. Subject-matter experts accept and use indications of system-wide issues related to safety from analyses of the database.	3/1	09/03 Comp Sep 03	2.1.7 (09/04) APMS TOOLS
2.1.5/6	**APMS for GA:** Demonstrate the potential applicability of APMS to GA.	Participation by the GA community in developing, adapting, and evolving APMS-like tools. At least, 2 major GA Leasers are providing data for operational analysis.	4/3	03/04	2.1/7 09/04 APMS TOOLS
2.1.5/7	**Merge FOQA Data with PDARS Data**: Demonstrate the ability and value to system-wide safety-risk assessment of merging FOQA data from a portion of the air carrier community with PDARS data from a portion of the ATC community.	Two major air carriers are providing FOQA data for merging with PDARS data from at least 3 ATC sites. Subject-matter experts accept and use the indications of system-wide issues related to safety from analyses of the database.	6/1	09/04	2.1.8 (09/04) APMS TOOLS

2.1.5/8	**Identify Vendors to Commercialize APMS Tools:** Identify and execute agreements with vendors who are interested in commercializing APMS tools.	At least one vendor has expressed interest in commercializing one or more of the APMS tools.	6/3	03/04	2.1/7 (06/05) APMS TOOLS
2.1.5/9	**Transfer APMS Tools to Vendors of Commercial FOQA Software Programs:** Enter into agreement with at least one vendor to transfer APMS tools for commercialization	Invention disclosure, patent applications, and licensing agreements in place allowing inclusion of marketable tools in COTS software. Formal agreement in place with at least one vendor committed to commercializing one or more APMS tools	6/3	06/05	2.1.7 (06/05) APMS TOOLS
2.1.5/10	**PDARS Operationally Proven at an Operational Site:** Software and network equipment demonstrated to show usability and value.	Software and network equipment have been transferred to the FAA to continue operation with all developed PDARS tools. FAA has formally accepted responsibility for continued day-to-day operation of PDARS and its network.	6/3	06/05	2.1.10 (06/05) PDARS TOOLS

Note: Milestones 2.1.5/2, 2.1.5/4, and 2.1.5/6 were previously assigned to element 2.1.1 before re-structuring in FY'01 established the element 2.1.5 Intramural Monitoring. Milestones 2.1.5/#4 and 2.1.4/#6 were subsequently deleted due to inadequate funds in FY'03 – '04.

TABLE 4.1 (D)
ELEMENT MILESTONE CHART -
2.1.2 EXTRAMURAL MONITORING

No.	Title/Description	Exit Criteria	TRL/IRL	Date (Mo/Yr)	Level II Roll-up (FY Quarter) PRODUCT
2.1.2/1 Pre-AvSP	**Hold NAOMS Workshop:** Conduct workshop to obtain industry inputs to survey design.	Community support for test trial of NAOMS	2/3	12/98 CompDec98	2.1/3(06/02) & 2.1/11 (06/05)
2.1.2/2	**Conduct Trial of Survey**: Conduct focused trial of NAOMS concept with air carrier pilots.	Community support for NAOMS implementation.	3/3	09/99 CompJan 00	2.1/3(06/02) & 2.1/11 (06/05 NAOMS)
2.1.2/3	**Implement Flight Crew Survey**: Implement the NAOMS prototype for the commercial air-carriers and to flight-crew sectors.	Active participation by significant portion of these communities. At least 60% of the survey questionnaires are completed.	5/3	06/01 Comp Apr 01	2.1.3(06/02) & 2.1/11 (06/05) NAOMS
2.1.2/4	**Implement Survey of Mechanics & Technicians:** NAOMS adds mechanics & technicians community to survey system.	Active participation by significant portion of mechanics/technicians community. At least 60% interview completion rate.	5/3	06/03	2.1/3 (09/02) & 2.1/5 (06/05) NAOMS
2.1.2/5	**GA Pilot Survey**: NAOMS adds the GA pilot community to the survey system.	GA survey launched with at least 800 interviews completed.	5/3	09/02 Comp Sep 02	2.1/3(09/02) NAOMS
2.1.2/6	**Demonstrate Use of NAOMS for Risk Assessment:** Demonstrate ability of NAOMS to generate valid hypotheses of precursors for system-wide safety-risk assessment.	Subject-matter experts (e.g., ATA, ALPA, AOPA, HAI, airlines) accept and agree that at least 75% of the hypotheses are plausible issues.	6/3	06/04	2.1/11 (06/05) NAOMS
2.1.2/7	Demonstrate Survey of Full NAS: The NAOMS is incorporating inputs from the air-carrier, commercial flight crew, air-traffic-control, cabin-crew, mechanics/technicians, corporate, and GA communities routinely.	Continued positive response from all of the solicited communities. At least 60% interview completion rate.	6/3	06/05	2.1/5 (06/05) NAOMS
2.1.2/8	Demonstrate Use of FOQA Data to Validate Problems Identified by NAOMS: Demonstrate that NAOMS reliably identifies system problems that are validated and quantified by FOQA data.	NAOMS verified as a source for generating hypotheses of precursors. At least 50% of problems identified related to FOQA are validated in FOQA data.	3/3	06/05	2.1/5 (06/05) NAOMS
2.1.2/9	Implement Survey of ATC and Cabin Crews: NAOMS adds ATC and Cabin Crew communities to the survey system.	Positive participation by a significant proportion of each of these communities. At least 60% interview completion rate.	5/3	09/04	2.1/5 (06/05)
2.1.2/10	**Establish NAOMS Working Group**: Establish a working group of aviation community members (industry and government) with whom study information can be shared and who can provide operational advice.	The Working Group is in place and first meeting held with participation by at least 70% of invitees.	6/1	09/03 Delayed to 12/03	2.1/11 (06/05) NAOMS

2.1.2/11	**Establish Methodology for Survey of ATC:** NAOMS prepares the survey package and conducts the field trials of air traffic controllers.	Indications from the field trials of positive participation by a significant (i.e., at least 60% return) of the representative group from the ATC community.	5/3	09/04	2.1/11 (06/05) NAOMS
2.1.2/12	**Demonstrate Value of Pilot Survey:** Analyze statistically the results of the survey to date to uncover and describe operationally significant features of the operation of the system.	Examples of operationally significant information are derived from the surveys of the air carrier and the GA Pilots. Subject-matter experts accept and agree with at least 75% of the issues identified.	6/3	06/05	2.1/11 (06/05) NAOMS
2.1.2/13	**Demonstrate Improved Methodologies for Cost-effective Surveys:** Demonstrate a reliable, efficient, cost-effective survey process that is ready to incorporate and integrate inputs from all of the air services communities for the full view of the NAS.	Subject-matter experts agree that the process is practical and extendable to routinely survey the constituencies of the aviation system. At least 75% agree that the informational benefits of a permanent service are worth the cost.	6/3	06/05	2.1/11 (06/05) NAOMS

NOTE: The Milestones 2.1.2/4 Implement Survey of Mechanics and Technicians, 2.1.2/7 Demonstrate Survey of Full NAS, 2.1.2/8 Demo Use of FOQA to Validate Problems Identified by NAOMS, and 2.1.2/9 Implement Survey of ATC and Cabin Crews were deleted due to inadequate projected funds based on cost experience of first survey of Flight Crews in FY'01.

TABLE 4.1 (E)
ELEMENT MILESTONE CHART
2.1.3 MODELING & SIMULATION

No. #	Title/Description	Exit Criteria	TRL/IRL	Date (Mo/Yr)	Level II Roll-up (FY Quarter) PRODUCT
2.1.3/1 Pre-AvSP	**Use of QUORUM Demonstrated:** Demonstrate use of QUORUM as model of anecdotal reports such as ASRS incident and NTSB accident reports.	Models of anecdotal reports are sufficiently reliable representations of meaning to automatically link relevant diverse sources.	3/3	09/98 Comp Sep 98	2.1/4 (09/03)
2.1.3/2 Pre-AvSP	**Initial Model Demonstrated**: Demonstrate capabilities of existing models	Models of human/system interaction operating in specific scenarios, risk calculations evaluated against historical data, and model deficits identified.	3/1	09/99 Comp Sep 99	2.1/4 (09/03)
2.1.3/3	**Models Based on Merged Data Demonstrated**: Use modeling capability to test safety risk assessment using merged information from ground, air, and environment.	A modeling hierarchy is operating in a demo merging ground, flight, company, and NAS-monitoring data to assess risk in a scenario with 4 human operators and 2 aircraft interacting with ATC.	3/1	09/00 Comp Oct 00	2.1/4 (09/03) FAST-TIME SIM OF SYS-WIDE RISKS
2.1.3/4	**System-wide Simulation Demonstrated**: Demonstrate capability to simulate the aviation system.	A framework of models is operating in simulation of NAS-wide operation for ground and flight with 2 terminal areas in app/dep ops and 2 en-route ops.	4/1	09/01 Comp Sep 01	2.1/4 (09/03) FAST-TIME SIM OF SYS-WIDE RISKS
2.1.3/5	**Predictive Capability Verified**: Demonstrate predictive capability of simulation using system-wide model(s) and verify using NAS data.	Models of NAS operational scenarios and output integrity are formally verified. All software performance parameters verified to within 1 standard deviation.	4/3	09/02 Comp Sep 02	2.1/4 (09/03) FAST-TIME SIM OF SYS-WIDE RISKS
2.1.3/6	**System-wide Risk Assessment Validated:** Demonstrate system-wide safety risk assessment using predictive simulations and validate using NAS data.	Structural and causal predictions of risk are produced in simulations. Assessments of systemic "risk factors & contexts" are evaluated against incident databases Correlation between model and NAS performance is 0.60 or better	5/3	03/03	2.1/4 (09/03) FAST-TIME SIM OF SYS-WIDE RISKS
2.1.3/7	**Merge FOQA Data with Models & Simulations:** Demo use of FOQA data to enhance, verify, and validate system models and simulations.	Subject-matter experts use capability to predict system-wide effects. At least 2 major air carriers are using simulations to aid evaluations of proposed interventions.	6/3	06/05	2.1/9 (06/05) FAST-TIME SIM OF SYS-WIDE RISKS
2.1.3/8	**Distributed Simulation Capability:** Prototype distributed simulation capability to assess risk by accessing data over a secure internet.	Ability to support distributed client-based analyses of safety risk with remote access to data sources is demonstrated and risk assessment accuracy is validated.	5/3	06/05	2.1/9 (06/05 FAST-TIME SIM OF SYS-WIDE RISKS

2.1.3/9	**Prediction of System-wide Effects of Changes Validated:** Demo validity of predicted statistics of workload and syst. perf. due to changes in contextual factors during specific scenario.	Correlation between statistics produced by simulation and those obtained from APMS, PDARS, and NAOMS is 0.60 or better..	6/1	09/03 Comp Sep 03	2.1/4 (06/03) & 2.1/11 (06/05) FAST-TIME SIM OF SYS-WIDE RISKS
2.1.3/10	**Demonstrate Linkage of Human Performance/Air Traffic Simulation to Data Sources and Automated Risk Assessment:** Fast-time simulation is linked to data sources (e.g., flight & weather) and output is linked to risk analysis tool.	Linkages perform as expected and at least 75% of the risk assessments are deemed plausible. Demo of potential risks & causal factors for TBM compared with MITM are accepted as valid by domain experts.	6/1	06/04	2.1/11 (06/05) FAST-TIME SIM OF SYS-WIDE RISKS
2.1.3/11	**Risk Assessment of System-wide Effects of Changes Validated:** Demo validity of safety risk assessments of the TBM vs. MITM scenarios.	Fully linked human perf./air traffic sim and risk analysis system is validated for TBM vs. MITM scenarios against APMS, PDARS, & NAOMS data. Subject-matter experts agree with predicted assessments in at least 75% of situations modeled.	6/1	06/05	2.1/11 (06/05) FAST-TIME SIM OF SYS-WIDE RISKS

NOTE: Milestones 2.1.3/6 System-wide Risk Assessment Validated, 2.1.3/7 Merge FOQA Data with Models & Simulation, and 2.1.3/8 Distributed Simulation Capability were deleted because of inadequate funding. Milestone 2.1.3/6 is replaced by Milestones 2.1.3/9, 2.1.3/10, and 2.1.3/11 that spread the same work over three years to accommodate reduced funding.

4.1.1 Data Analysis Tools Development (ASMM WBS Element 2.1.1)

Goal(s)

The contribution of *Data Analysis Tools Development* to the goal of ASMM is to facilitate efficient, penetrating, and insightful analyses of textual and numerical data collected by the various components and stakeholders of the NAS to identify causal factors, accident precursors, and unsuspected features related to health, performance, and safety of the NAS.

Objective(s)

- Develop tools that convert data from diverse, heterogeneous new and legacy databases into information, and create visualization capabilities that aid aviation/safety experts conduct causal analyses and safety-risk assessments.
- Demonstrate the capabilities and values of these tools so as to encourage the aviation communities to adopt their use and invest in their continuing evolutionary developments.

Approach

The torrent of new data to be analyzed as the US air carriers begin to acquire flight-recorded data routinely under the FOQA program and textual data under the ASAP program, and as ATC acquires radar data routinely under the PDARS program will overwhelm the capabilities of human analysts. Consequently, the opportunity to capture safety-related information and to utilize it proactively across the aviation system will be lost. Advanced tools must be developed for efficiently converting digital and textual data into reliable information that is operationally useful for assuring safety and quality performance.

The research done in this element called *Data Analysis Tools Development* will improve our ability to manage incoming data of all kinds and extract useful safety information from them. Based on our experience with both ASRS and APMS, we see a need for several automated capabilities that, together, will assist the analyst in uncovering and understanding the circumstances and features of an incident, and in assessing the risk of its leading to an accident. Further, we must develop the capabilities to link all such information in order to analyze reliably for the causal factors (precursors) of all incidents and to support a process of safety-risk assessment that is, in fact, the primary capability needed for proactive management of quality assurance. The efforts under the *Data Analysis Tools Development* element will result in advanced software that will be able to perform many tasks that only experts can presently perform with much effort. As a result, data will be better classified, more easily prioritized, more readily combined with pertinent data from other sources, and data patterns will be better understood. Data processing costs will decline because the analytic capability of humans will be supplemented by knowledge-based automation.

In the development of each of these capabilities, we will select state-of-the-art tools that are adaptable to meet our needs for aviation safety analysis. We will use commercial off-the-shelf (COTS) capability whenever possible and we will augment COTS tools as necessary to fill any critical gaps just as we have for APMS. We will use these tools to explore data collected under both the *Intramural* and *Extramural Monitoring* efforts, and, on the basis of that work, we will refine, enhance, and augment the tools as necessary. We will test and evaluate these advanced tools in the operational environment in collaboration with our partners at the air carriers, the FAA ATC, and the vendors of COTS software for data processing. The roadmap of activities and the key milestones for the *Data Analysis Tools Development* are presented in Figure 4.1(D) and Table 4.1 (B).

The primary technical challenges to developing and implementing a set of data analysis tools <u>in the operational environment</u> are the following:

- Routinely process very large quantities of data effectively and economically.
- Convert data into information that is immediately and reliably meaningful to each individual user.
- Automatically analyze textual databases and knowledgeably merge information with numerical databases.
- Extend the capabilities system wide.

The identified needs are listed below. While each has value in itself, they are not independent developments. In the order in which they are presented below, they are incremental steps toward the ultimate objective of providing the information from diverse data sources for reliable causal analysis and safety-risk assessment from a system-wide perspective.

- Taxonomies
- Automated Analyst Advisor
- Machine Comprehension of Free Text
- Database Linkage
- Database Mining
- Visualization of Information
- Causal Analysis
- Safety Risk Assessment

A significant milestone in the development of advanced tools was achieved in FY'02 with the demonstration of an operational test of risk assessment aids that supported the Level III Milestone of the same title. Up to that point, we had been building these tools as independent, stand-alone capabilities. In FY'02, we demonstrated, for the first time, the potential value of using these tools in concert

- to access information extracted from diverse data sources,
- to understand the causal factors, and
- to assess the risk of an identified anomalous event
- from a system-wide perspective.

We used each of the ASMM tools in a set of (nearly) independent studies of the same scenario; namely, in-close approach changes

- to demonstrate the kinds of information that each data source and tool can potentially contribute to gaining insight into the complete picture of causal factors and safety risks, and
- to show the methodology for utilizing each of the tools in a complementary and synergistic process of causal analysis and safety risk assessment to aid the decision makers.

By the end of the current program in FY'05, we will have developed the tools to extract the information automatically from each of these diverse sources that is relevant to any query or scenario. In FY'02 and FY'03, our focus was on processing and analyzing digital data. In FY'04, these capabilities will be in operational test and evaluation under the *Intramural Monitoring* element and the focus of analytical tool development will be on textual data. Also in FY'04 we will demonstrate how these capabilities can assist decision-makers in assessing safety risk from a system-wide perspective. Information will be extracted automatically from digital data sources, such as APMS and PDARS data, and utilized in an automated risk assessment capability. In FY'05, we will augment this with the capability of extracting information from textual databases such as ASRS, ASAP, and NAOMS and automatically integrating it with information from digital databases for improved risk assessment.The primary contractor in *Data Analysis Tools Developments* is Battelle and collaborations/sub-contracts are, or have been, with the Pacific Northwest National Laboratories, the FAA Office of System Safety, Rannoch Corp., Sandia National Laboratories, the Flight Safety Foundation, Virginia Polytechnic Institute, Oregon Graduate Institute, SUNY Stoneybrook, UC Riverside, the Naval Research Laboratory, and ONERA.

Milestones/TRLs

Refer to Table 4.1(A) for the ASMM sub-project Level II Milestones and to Table 4.1 (B) for the Level III Milestones for the *Data Analysis Tools Development* element. These Tables show the Titles and Descriptions of the milestones, their exit criteria, their technology readiness levels (TRL) and implementation readiness levels (IRL), the roll-up to the next level milestone(s), and the specific product with which the milestone is associated.

4.1.2 Intramural Monitoring (ASMM WBS Element 2.1.5)

Goal(s)

The contribution of *Intramural Monitoring* to the goal of ASMM is to assist and enable air services providers to establish the capabilities within their own organizations for proactive management of safety risk.

Objective(s)

- In partnership with air carriers providers, build intramural airline-safety monitoring capabilities by testing and evaluating data analysis tools in the airline operational environment and by extending and adapting the concepts and methodologies of APMS to new applications and environments.
- In partnership with the FAA and NATCA, build intramural ATC-safety monitoring capabilities by testing and evaluating data analysis tools in the ATC operational environment and by extending and adapting the concepts and methodologies of APMS to ATC applications and environments.
- Develop a contribution to the data sources needed to support system-wide research issues, enable the development, calibration, and validation of system-wide models, and establish the baseline of operational performance against which to measure changes.

Approach

This element establishes and maintains collaborations with the operational sectors to obtain the perspectives, the operational data, access to other relevant databases, and the users' evaluations in the operational environment essential to evolving a suite of data-analysis tools offering maximum benefits at minimal cost. The collaborations are conducted under Space Act Agreements (SAA) with the individual users and the vendors and the work is maintained within the walls of each collaborator to maximize the potential for developing the concept for information sharing while minimizing the concern for misuse of data. The roadmap of activities and the key milestones for the *Intramural Monitoring* element are presented in Figure 4.1 (E) and Table 4.1 (C).

We will build on the successful APMS monitoring capability of flight-recorded data on commercial air transports and extrapolate these concepts and methodologies to enable other aviation environments to monitor their own performance. Transferring the data-analysis technology to all operating carriers, to ATC and, one day, to the GA community, is the fundamental, essential step to establishing the database that will become the essence of system-wide safety risk assessment and sharing of information across the entire community. However, it must start intramurally within each organizational element of the system. The proven approach used in the APMS program of working collaboratively with the individual users will continue.

On the air-carrier side, we will continue to evolve the suite of tools to convert flight-recorded data to information on flight operational performance under the SAA's with Alaska Airlines and with American Airlines. During FY'03, we entered into an SAA with Delta Airlines. This gives us access to a significant new source of operational data and domain expertise with which to test and continue to evolve data analysis capabilities. APMS concepts need to be extended from the current focus on flight operations to monitoring routinely aircraft and subsystem health for precursors to system incidents, to support proactive strategic planning of on-condition maintenance, and to improve flight-crew training by responding quickly to identified problems of performance. The developments of applications of APMS to all of these areas must start within each individual operator as no two pursue their quality-assurance programs in engineering, maintenance, and training exactly the same way. It is important only that the output information from these analytical processes be sufficiently standardized to enable sharing of meaningful information when the operators choose to do so.

We work with the air carriers in an iterative, evolutionary development of a series of progressively more sophisticated builds. This approach enables the user to become familiar with the capabilities of the data analysis tools in a gradual learning process, and to base his requests for the next level of capability on this "hands-on" experience. It also enables the user and the vendor to agree on which tools merit consideration for commercialization. These developments have been, and will continue to be, cooperative in nature, with partners providing matching in-kind resources. NASA's job is done when the air carriers have implemented their intramural monitoring systems and the vendors have marketed the necessary capabilities.

Further, we will extend these concepts and methodologies for data analysis to performance measurement within the ATC community in much the same way as they are being extended intramurally within the air carriers. The methodologies and concepts developed for flight operations of major air carriers will be extended to meet the informational needs of air traffic management. We have established collaborations with the ATC community (FAA and NATCA) to obtain the perspectives, the operational data, access to other relevant databases, and the users' evaluations essential to evolving a suite of data analysis tools in support of the FAA's Performance Data and Analysis Reporting System (PDARS). The system provides daily reporting of processed data by time and place showing traffic counts, deviations, display of aircraft tracks, and replay capability that can be shared by all facilities on the network. The work is contained within the ATC community to maximize the potential for developing the concept for information sharing while minimizing the concern for misuse of data. Under the *Data Analysis Tools Developments* task area, we will develop the algorithms that will allow APMS concepts to be extended from air carrier flight operations to air traffic control, and we will apply these technologies in the field. The ATC environment presents a particular and special technical challenge to establish the appropriate and useful performance metrics.

The test and evaluation of the PDARS concept started in FY'00 with installations at and networking of the facilities of the Western-Pacific Region and the National Traffic Management Center in Herndon, VA. By the end of FY'02, the PDARS network had been extended to include the facilities of the Southwestern and Southern Regions. During FY'03, we obtained approval of a National Procedure Change (NPC) for one year that enables the extension of the test and evaluation of PDARS to all 20 Centers of the continental U.S. This extension of the secure PDARS network will be completed in FY'04.

Fundamental to the concept of proactive management of risk is the need to access diverse sources of data and to share information for collaborative decision making. We have found that, even within the most advanced air carriers, there does not exist an efficient infrastructure to share information quickly and reliably across intramural sectors. The same situation maintains among the facilities of the ATC community. In the "bottom-up" aspect of monitoring the system, there is a need for the infrastructure to enable the sharing of aviation safety information across each organization's internal operations. Until this need is met within the organizations, the ASMM sub-project will not be able to achieve its broader system-wide safety objectives that rely on sharing such information across organizations and nations. NASA Ames has unique and well-regarded expertise in the development and utilization of sophisticated middleware (software that smoothes the transfer, translation, and combination of data drawn from different sources); and reliable information security systems. Therefore, as we evolve the data analysis tools within each organization, we will also assist each organization develop its internal infrastructure for sharing the information created by these tools. Then we will develop a secure network infrastructure that provides access to safety-relevant information developed within the organizations, and adapt commercial off-the-shelf software for automated data-handling services that provide translation, integration, and validation services to support system-wide applications and queries.

The milestone for FY'04 calls for the identification of vendors to commercialize APMS tools. Disclosures of Invention have been processed for five digital-data processing and analyses tools. In FY'05, we will transfer the APMS tools through licensing and we will transfer the PDARS network and software to FAA Air Traffic Services.

In developing the intramural capabilities for monitoring these operations, as in the development of the extramural monitoring, progress will depend on engaging the active involvement of the aviation community.

The primary contractor in this element of *Intramural Monitoring* is Battelle and collaborations with the FAA Office of System Safety, FAA Office of System Capacity Requirements, ProWorks, and the ATAC Corp. APMS and PDARS are identified as ASMM deliverable products.

Milestones/TRLs

Refer to Table 4.1(A) for the ASMM Sub-Project Level Milestones and to Table 4.1 (C) for the Level III Milestones for the *Intramural Monitoring* element. These Tables show the Titles and Descriptions of the milestones, their exit criteria, their technology readiness levels (TRL) and implementation readiness levels (IRL), the roll-up to the next level milestone(s), and the specific product with which the milestone is associated.

4.1.3 Extramural Monitoring (ASMM WBS Element 2.1.2)

Goal(s)

The contribution of *Extramural Monitoring* to the goal of ASMM is the "top-down" element of the dual strategy for monitoring. This element aims at establishing the methodologies for a permanent field implementation of a National Aviation Operational Monitoring Service (NAOMS) responsible for developing and maintaining a comprehensive and coherent survey of the safety and performance of the NAS.

Objective(s)

- Develop comprehensive survey methods for monitoring the overall state of the National Aviation System.
- Provide decision makers in air carriers, air traffic management, and other air services providers with regular, accurate, and insightful measures of the health, performance, and safety of the National Aviation System.
- Ensure that changes of technology or procedures introduced into the system are producing expected improvements without producing unwanted side effects.
- Develop a contribution to the data sources needed to support system-wide research issues, enable the development, calibration, and validation of system-wide models, and establish the baseline of operational performance against which to measure changes.

Approach

<u>National Aviation Operational Monitoring Service (NAOMS)</u>

It is necessary to find a source of aviation data and to create a data-collection mechanism that is expressly tailored to the objectives and needs of AvSP. After careful consideration of the alternatives at the outset of this study, it appeared that the best way to develop such data is to survey the operators of the aviation system (i.e., its pilots, controllers, mechanics, dispatchers, flight attendants, and others) on a regular basis. The 27-year history of the Aviation Safety Reporting System (ASRS) had demonstrated to us the value of user reporting in creating feedback on the day-to-day operation of the NAS. This element aims at developing and validating the methodologies for a permanent implementation of NAOMS (an ASMM deliverable product) to maintain a comprehensive and coherent survey of the safety and performance of the NAS. The roadmap of activities and the key milestones for the *Extramural Monitoring* element are presented in Figure 4.1 (F) and Table 4.1 (D).

The purposes of this effort are to:

(1) Create a mechanism to routinely measure the safety of the NAS in a quantitatively precise way,

(2) Demonstrate the use of this mechanism to assess trends in NAS safety and to identify the factors driving those trends, and

(3) Identify safety and efficiency effects of new flight and Air Traffic Management (ATM) technologies and/or procedures as they are inserted into the operating environment.

Keys to the success of NAOMS include:

1) Plausibility and understandability of NAOMS statistics (e.g., reasonable and reliable representation of the relative frequencies with which unwanted events occur),
2) stability and interpretability of NAOMS statistical trends,
3) sensitivity to industry concerns about data misuse, and
4) timely and appropriate disclosures of NAOMS findings.

This list is not exhaustive, but it points to several related ideas with a common root. The data NAOMS collects must yield indications of system safety that are interpretable and deemed credible by the industry. NAOMS data must be seen as providing useful information that ultimately supports actions (or in some cases, justifies inactions) that make the NAS a safer place in which to fly.

Accordingly, the NAOMS Team has devoted a great deal of energy to developing a methodologically sound survey process. Trade-offs have been made among precision, accuracy, and cost. The main variables that can be manipulated to accomplish these tradeoffs are sample size and the recall period. The very successful Field Trial of NAOMS in FY99/00 entailing more than 600 interviews helped us to quantify those trades.

The Field Trial also showed us that a few outlier observations of severe events could have a substantial effect on the calculated average frequencies for many safety events and, therefore, on the statistical stability of calculated event frequencies. Fortunately, statistical methods are available that will allow the NAOMS team to generate stable period-to-period estimates of average event frequencies while identifying outlying values that may point to localized risk issues.

NAOMS must be able to distinguish operationally meaningful changes in event frequencies from year-to-year. This is much more demanding then generating single-point estimates for just one year. Based on the mean tendencies and variability observed in the Field Trial data, the NAOMS Team concluded that 8000 observations per constituent group (i.e., air carrier pilots, GA pilots, controllers, mechanics, etc. are each one constituent group) would probably yield data of sufficiently fine resolution to detect year-to-year event rate changes of 20 percent or more with a high degree of certainty (except for the rarest event types). This is the sample size that was employed in FY01 for the survey of commercial flight crews.

The first survey target group was active commercial pilots. The survey of the air carrier pilots was initiated in April 2001. By September 30, 2002, well over 10,000 interviews had been completed and the response rate exceeded the 70% goal. The second target group included GA, corporate, and helicopter pilots. This survey was initiated in August 2002. By September 30, 2002, 656 interviews had been completed and, again, the response rate exceeded 70%. With the implementation of the GA-pilots' survey under NAOMS, the Level II and Level III Milestones of FY'02 were achieved.

A crucial, practical measure of NAOMS success is its ability to support the aviation community in its assessment of safety risks and the efficacy of government/industry interventions. Accordingly, NAOMS has cultivated a close association with the aviation industry and organized labor including CAST. The JIMDAT Team of CAST sees NAOMS as a valuable tool for measuring the system-wide impacts of the interventions that their JSAT Teams have developed. NAOMS will actively support this process by incorporating core Safety Event questions that address CAST priorities and by developing Topical questions that address focused safety concerns.

By the end of FY'03, NAOMS will have accumulated a significant database of pilot interviews. However, it is important to obtain the inputs from the air traffic controllers for a balanced perspective on the NAS operations. Although there are insufficient funds in the program to undertake a full survey of the ATC community, we will establish the methodology for such a survey as reflected in the Level III Milestone for FY'04. The NAOMS Team will prepare the survey package and conduct the field trials of the air traffic controllers.

There has been reluctance on the part of the NAOMS Team to release information from the survey that might be viewed by some sectors of the community as sensitive, controversial, or premature. Nevertheless, it is important to demonstrate to the community the value of the survey process. The establishment of a NAOMS Working Group as a Level III Milestone in FY'03 is consistent with this continuing effort to keep NAOMS tuned to the perceived informational needs of the aviation community. The resolution of some issues of membership and objectives delayed the first meeting of this group to December 2003. This working group is composed of aviation community members (representing both industry and government) with whom study information can be shared and who can provide advice on the operation of the NAOMS and on the dissemination of possibly sensitive information. The Level III Milestone in FY'05 provides for a demonstration of the value of the NAOMS concept based on the statistical analyses of the survey of the pilots to that date. The purpose will be to show examples of operationally significant information that have been derived solely from the surveys of the air carrier and the GA pilots. This Level III Milestone rolls-up into the Level II Milestone 1.10.

All of these considerations enter into the quantified definitions of the exit criteria as they are stated in the Milestone Charts of Tables 4.1(A) and 4.1(D). However, these are merely current estimates based on the understanding gained from the field trials and the pilot surveys. The methodology continues to evolve, particularly as we look to minimize costs. The sample sizes and sampling rates for desired accuracy and precision may well be different for each constituent community. Therefore, these requirements will evolve as new sectors are incorporated into the survey and further experience is gained during program operation. A Level III Milestone in FY'05 is to demonstrate improved methodologies for cost-effective surveys. The objective is to demonstrate by FY'05 a reliable, efficient, cost-effective survey process that is ready to incorporate and integrate inputs from all of the air services communities for the full view of the NAS.

A primary requirement for the implementation of this survey service is finding a permanent "home" and funding. NASA will have developed the scientific methodologies to maximize the useful information and minimize the cost, but the AvSP does not provide for the permanent service after the concept is developed and its value proven.

System-wide Incident Reporting Enhancements

One of the many diverse sources of existing information on the health and performance of the aviation system is the Aviation Safety Reporting System (ASRS) managed by NASA and funded by the FAA Office of System Safety. The ASRS is one of the world's best-known and most highly regarded repositories of safety information. It has received nearly 500,000 safety reports from throughout the aviation community over its 25-year history. While the ASRS per se is not formally an activity of the AvSP, it was the experience with the ASRS that stimulated the development of the NAS Operational Monitoring Service (NAOMS) as the "top-down" element of the dual strategy of monitoring of the ASMM Project. Furthermore, the ASRS offers a database for testing and evaluating of some of the tools for processing and analyzing anecdotal data that are being developed under the ASMM Project. However, many of the underpinning ASRS operations are legacy system, built in the early to mid-1980s. Its infrastructure must be upgraded to enhance its efficiency and the quality of its diagnostic processes. Further, ASRS was constructed as a standalone information system before the advent of the Internet and other modern networking tools. Studies have identified the requirements to update the processing of ASRS reports, but these have not been implemented due, in part, to concerns for maintaining confidentiality and, in part, to inadequate funding. This area of research will tackle those needs. ASRS extensions will be accomplished through upgrades of the supporting infrastructure, improved capabilities such as electronic report submission, and test and evaluation of an analyst decision-support system to be developed under *"Data Analysis Tools Development"*.

The AvSP will benefit from the convenient and knowledgeable access to this unique "test bed" for capabilities that will ultimately be needed for the NAOMS and other sources of textual data. The ASRS will benefit from upgrading its legacy systems to state-of-the-art capabilities for managing, processing, and accessing textual incident reports. The aviation community will benefit from having ASRS data more accessible and better connected to other aviation safety resources as an element of the AvSP monitoring concept. We will also explore other similar data sources such as the ASAP and we are developing an intramural text-processing capability to interface with that program. The first generation of that capability is to be tested under the *Intramural Monitoring* element during FY'04 in collaboration with American Airlines under an SAA.

The primary contractor in this element is Battelle and collaborations/sub-contracts are with the Center for Public Health Research and Evaluations, Ohio State University, and Dodd Associates.

Milestones/TRLs

Refer to Table 4.1(A) for the ASMM Sub-Project Level Milestones and to Table 4.1 (D) for the Level III Milestones for the *Extramural Monitoring* element. These Tables show the Titles and Descriptions of the milestones, their exit criteria, their technology readiness levels (TRL) and implementation readiness levels (IRL), the roll-up to the next level milestone(s), and the specific product with which the milestone is associated.

4.1.4 Modeling and Simulations (ASMM WBS Element 2.1.3)

Goal(s)

The contribution of *Modeling and Simulations* to the goal of ASMM is to support reliable prediction of the impact of new technologies and procedures on operations, communications, and, in particular, the potential for human error. Models and simulations (an ASMM deliverable product) will be validated with data obtained from *Intramural* and *Extramural Monitoring*. These predictions will identify the system-wide effects of design or procedural changes introduced into, or proposed for, the National Aviation System.

Objective(s):

- Evaluate extant system and human-performance models, for applicability to system-wide representations
- Identify human-performance characteristics contributory to the safety of NAS operations; sensitivities of these characteristics to changes in design, procedures, and training; and requirements for human-performance models to fill gaps in modeling technologies,
- Develop empirical evaluation methods to validate models as reliable bases for causal analyses and safety risk assessment.
- Develop simulations to support reliable prediction of the system-wide effects of new technologies or procedures.

Approach

A proactive approach to ensuring the continued performance and safety of the National Aviation System (NAS) requires a capability for modeling and simulation in order to predict the effects of changes in operational procedures or new technologies before they are implemented. The objectives of the *Modeling and Simulation* sub-element are to establish consistent and predictable relationships among elements of the NAS with emphasis on incorporating appropriate human behavioral models. We will develop a rigorous and effective methodology for validating the models against measured data. The simulation sub-element will establish the operating conditions and the performance parameters to answer queries about a range of technology developments by exercising models of the system. The roadmap of activities and the key milestones for the *Modeling & Simulations* element are presented in Figure 4.1 (G) and Table 4.1 (E).

Models

This element provides for the development of tools for modeling the NAS at a level of detail sufficient to track key safety characteristics to support prediction and decision-making. Our work is to develop models that explicitly incorporate human performance into existing NAS modeling tools appropriate for representing system-wide operations. We expect to develop a hierarchy of models appropriate to the variety of questions that will be addressed, and to structurally characterize the relationship between incidents and accidents.

Modeling the elements of the NAS including the human participants in that system serves as a computational test bed for simulating and analyzing system performance, including the contributions of individual operators, individual elements of the system, technologies and large-scale system flow and control issues.

Simulations

The models of the system elements will need to be exercised in simulation to predict system performance. This sub-element provides for using computer simulations to test continuously the models and to identify errors or gaps as models are developed for system-wide assessment. Data and information obtained by the *Intramural* and *Extramural Monitoring* processes will be used to validate and verify the prediction of the system models. Simulation can be undertaken at time-references that are of particular interest to the analyst (fast, slow, and real time). We will use fast-time simulations (an ASMM deliverable product) to support safety risk assessment, identify performance metrics, and focus requirements for the more expensive man-in-the-loop simulations.

The primary contractor for this work is Battelle and collaborations/sub-contracts have been, or are with, the ATAC Corp., San Jose State University, Georgia Tech, the Rannoch Corporation, the Sandia Laboratories, the Naval Research Laboratory, and the Flight Safety Foundation. Glenn Research Center is responsible for the work on modeling and predictions of engine problems from the perspective of system-wide effects.

Milestones/TRLs

Refer to Table 4.1(A) for the ASMM Sub-Project Level Milestones and to Table 4.1 (E) for the Level III Milestones for the *Modeling & Simulations* element. These Tables show the Titles and Descriptions of the milestones, their exit criteria, their technology readiness levels (TRL) and implementation readiness levels (IRL), the roll-up to the next level milestone(s), and the specific product with which the milestone is associated.

4.2 SUB-PROJECT/ELEMENT CAPABILITIES AND PRODUCTS

The ability to monitor continuously, convert the collected data into reliable information, and share that information among the stakeholders in the aviation system for collaborative decision making is the basis for a revolutionary, proactive approach to managing the aviation system. The end products of the ASMM element are to provide the industry with the tools and methodologies to enable this proactive approach to the prevention of accidents. Figure 4.2 (A) shows the ASMM products (highlighted in italics), capabilities, system analyses and benefits. Table 4.2 shows the ASMM deliverable Products including the targeted problem.

Aviation System Monitoring and Modeling

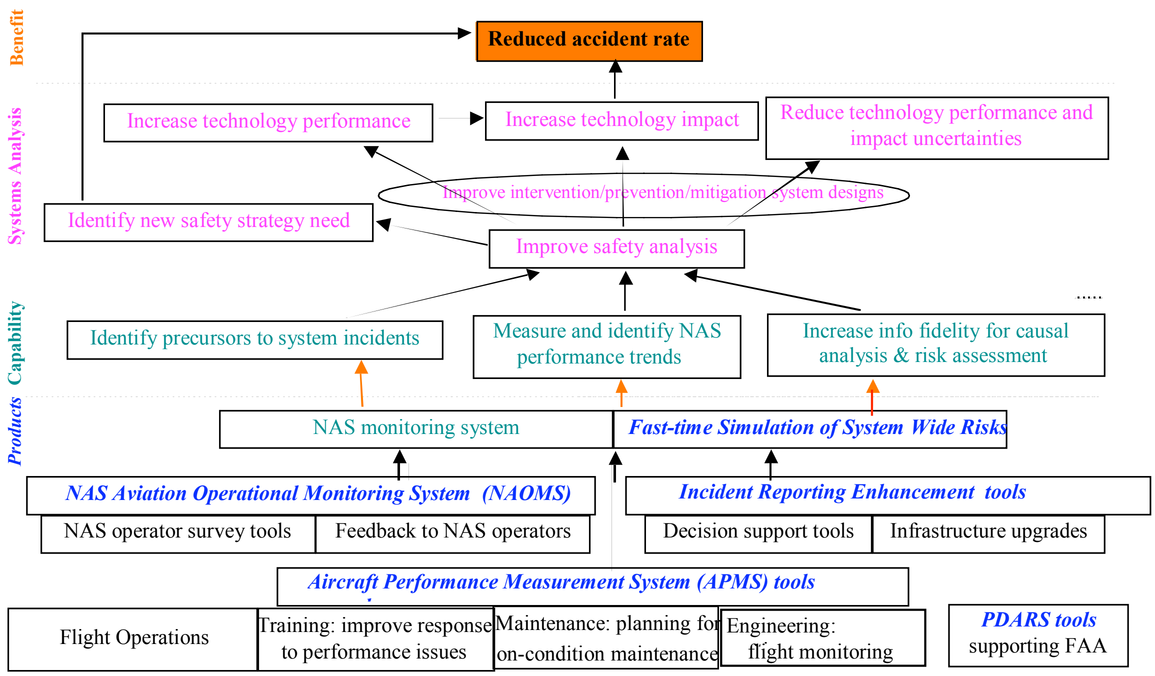


FIGURE 4.2 (A)
ASMM PRODUCTS, CAPABILITIES, SYSTEM ANALYSIS & BENEFITS

The flow chart of Figure 4.2 (A) indicates the key roles that the ASMM products play in the process of analyzing both quantitative (e.g., APMS and PDARS) and anecdotal (e.g., NAOMS, and ASRS) data to identify and evaluate precursors and performance trends. Formulation of an intervention strategy requires capabilities for causal analyses and safety-risk assessments (e.g., fast-time simulations). These lead to improved safety analysis and more reliable intervention strategies for the prevention of accidents.

Each of these ASMM Products has stand-alone capabilities that continue to evolve as the Data Analysis Tools are adapted to meet the needs of the constituency and for which it was primarily developed. However, the true and overriding value of the ASMM Products is as an integrated suite of tools to enable the achievement of the ASMM objective of providing a system-wide perspective on proactive management of the safety risk of the NAS.

TABLE 4.2
ASMM PRODUCTS

Product Name and Definition	Product Form	Exit Criteria	Customer/End User	Targeted Performance	Milestone LII #
System-wide Incident-reporting: Upgrade of the 27-year old technology of the ASRS database to include: conversion of ASRS legacy database to ORACLE; electronic submission of reports; and test and evaluation an analyst decision-support system	Database converted to ORACLE, hardware and software to permit electronic report submission and testing of analyst advisor system.	Electronic report submission and analyst's workbench are used in day-to-day operation of processing ASRS reports. Applications to other reporting system (e.g., ASAP reports and NAOMS survey) are demonstrated.	FAA, airline operators, flight crews, cabin crews, mechanics, ATC, and researchers in aviation safety and human factors	Improve collection and utilization ad hoc anecdotal safety reports from front-line NAS-wide personnel	#1.2 & #1.11
Fast-time Simulation of System-wide Risks: Rigorously validated system-wide models and simulations of relationship among elements of the NAS to support predictions and safety-risk assessments of system-wide effects of new flight and ATC technologies and/or procedures before they are inserted into the operating environment. Includes engineering models, operating concept models, support/logistics models, human performance models and risk analyses	A hierarchy of mathematical models	Structural and casual predictions of risk are being produced. Risk assessments are evaluated against incident and intramural databases for specific "risk factors and contexts". A measure of predictive accuracy (i.e., correlation between model and NASA performance) of .60 or better is calculated for model's performance	FAA, NASA and researchers in aviation safety and human factors	Ability to assess the system-wide safety impact of new technologies or procedures before they are implemented	#1.4 & #1.11
Prototype System-wide Risk Assessment Capability: A capability that demonstrates the feasibility and value of automatically merging de-identified disparate data sources to assess system-wide safety risks	PC-based software, documentation, training and guidelines for its utilization	At least 2 major air carriers and the ATC are sufficiently satisfied with validity of predictions to be using the ASMM tools for causal analysis and risk assessment and for fast-time simulations to aid evaluations of proposed interventions.	FAA; All personnel in the aviation industry including flight crews, cabin crews mechanics, technicians, ATC, airport operations and researchers in aviation safety and	Creation of capability to (1) provide decision makers with reliable information on safety of NAS; (2) identify causal factors, accident precursors, and off-nominal conditions;	#1.8 & #1.11

TABLE 4.2
ASMM PRODUCTS
(CONTINUED)

			human factors	(3) enable and encourage sharing information	
Aviation Performance Measuring System (APMS) Tools: APMS is an integrated suite of tools to facilitate implementation of routine flight-data analyses within each air-service provider. APMS develops and documents the software and procedures for data management and analyses of flight-recorded data that enable users to interpret implications in safety and efficiency of flight	PC-based software, documentation, training and guidelines for its utilization	At least 2 major air carriers are providing FOQA data for merging into a common database. Subject-matter experts accept and use indications of system-wide safety issues from analyses of the database.	Air carriers and general aviation operators - all functional disciplines, including flight operations, training, engineering and maintenance	Enable each user to implement a policy of proactive management by monitoring and analyzing large masses of flight-recorded data on a continuous basis	#1.2 & #1.7 & #1.8 & #1.11
Performance Data Analysis and Reporting System (PDARS) Tools: Provides the capability to: collect, extract, and process ATC operational data; compute quantitative operational performance measures on a regular basis relating to safety, delay, flexibility, predictability and user accessibility; conduct causal analyses and operational problem identification and analyses; access design and simulation tools for "what-if" analyses and for identification and emulation of system improvement options; achieve performance statistics and basic operational data for use in research development and	Hardware: PCs, printers, tape drives, desktop software; Networking: Routers, hub, switches, DSL & T1 lines; Taps: to TRACONs and Centers; Software: tap client, server client modules, central merge process, site adaptation; User materials: Customized sample report	Acceptance by the ATC community and extension to other sectors of national ATC. At least 14 facilities are actively participating in evaluation, and plans for nationalization are made by the FAA	FAA	Continuous, routine monitoring of performance metrics to enable the implementation of a policy of proactive NAS management	#1.1 & #1.2 & #1.8 & #1.9 & #1.11

planning studies	scripts, help information and manuals, training				
National Aviation System Operational Monitoring System (NAOMS): Aims at the permanent field implementation of NAOMS responsible for developing and maintaining a comprehensive and coherent survey of the safety and performance of the NAS from the perspective of front line personnel NAS-wide. it is a proactive companion to the ad hoc submittal process embodied within ASRS	Survey tool and validated methodology	Continued positive response from all of the solicited communities. At least 60% interview completion rate	FAA; All personnel in the aviation industry including flight crews, cabin crews mechanics, technicians, ATC, airport operations and researchers in aviation safety and human factors	Creation of a mechanism for measuring the overall safety of the NAS in a quantitative, precise and repeatable way on an ongoing basis	#1.2 & #1.3 & #1.10

From another perspective, the matrix of Figure 4.2(B) portrays the relationships of the products of the ASMM sub-project to the four primary steps of the process of proactive management of safety risk. The key attribute of all of these products is to facilitate efficient and insightful analyses of all relevant data to identify causal factors, accident precursors, and unsuspected features in the data collected pertaining to the health, performance, and safety of operations in the NAS. Consequently, as indicated in Figure 4.2(B), NASA's role in the process is predominantly to aid IDENTIFYING and EVALUATING. For the most part, it is up to the experts in industry and the FAA to FORMULATE and IMPLEMENT the interventions. However, it is in these latter two steps that ASMM developments in modeling and simulations will aid in predicting system-wide effects of proposed changes and developments in information sharing will aid the collaborative decision-making process.

	PRODUCTS			
	DATA ANALYSIS TOOLS	APMS PDARS	NAOMS INCIDENT REPORTING UPGRADES	FAST-TIME SIMULATION OF SYSTEM-WIDE RISKS
IDENTIFY				
Monitor and Compare with Expectations	●	●	●	●
Uncover Potential Risks	●	●	●	●
Recognize Improvements	●	●	●	●
EVALUATE				
Diagnose Causation	●	●	●	●
Quantify Frequency	●	●	●	●
Assess Severity	●	●	●	●
FORMULATE				
Consider Change	●			●
Assess Safety Benefits & Risks				●
Estimate Economic Benefits & Costs				
IMPLEMENT				
Implement Locally				
Evaluate Intervention	●	●	●	●
Refine				●
Implement Full-Scale				

● Denotes an area where ASMM tools, methods and datasets will enable proactive risk management

FIGURE 4.2(B)

RELATIONSHIPS OF ASMM PRODUCTS TO THE PROACTIVE MANAGEMENT PROCESS

4.3 METRICS

4.3.1 Safety Goal Metrics

Assessment of the safety goal impact of Aviation System-wide Monitoring will be evaluated in three ways.

- The first method will track progress toward raising the TRL of the ASMM project's products.
- The second method will be the overall degree of aviation community penetration of the ASMM products. The success levels are specified in the exit criteria for each ASMM product.
- The third method will be the degree of system-wide integration accomplished amongst the ASMM products. This integration provides both system-wide analysis capabilities as well as the feedback & validation capabilities that will be crucial for this unique capability.

  - Minimum success will be the demonstration of heterogeneous integration of ASRS, APMS, NAOMS, and PDARS to assess specific operational issues of the NAS.
  - Full project success will include system-wide predictions that are validated by the monitoring and data analysis tools.

4.3.2 Project Success Metrics

Assessment of the success of the Aviation System Monitoring & Modeling (ASMM) will be primarily by tracking progress toward raising the TRL of the project's products. A secondary metric, where applicable will measure a technology's ability (at any given TRL) to meet the element's target performance goals. Success of the ASMM sub-project will be based on four additional criteria:

- Ability to meet Project milestones within cost, schedule and resources.
- Ability for ASMM enabling technologies to achieve Technology Readiness Levels (TRL) as shown in Tables 4.1(A) through 4.1(E).
- Ability of ASMM enabling technologies to sufficiently impact AvSP goals.
- Ability of ASMM enabling technologies to be implemented into the aviation community.

Project and Element milestones will be tracked by the AvSP on a monthly basis as well as cost, schedule and technical progress down to the sub-element level. Each Element milestone will be tied into a Project milestone. Project status will be evaluated as follows:

a. Major Problem
   Schedule: Milestone delayed more than 1 quarter
   Cost: More than +/- 15% of planned cost
   Technical: Problems meeting most of exit criteria
b. Minor Problem
   Schedule: Milestone delayed between 1 and 4 months
   Cost: Between 10-15% of planned cost
   Technical: Problems meeting some exit criteria
c. No Known Problem
   Schedule: On (<1 month) or ahead of baseline schedule

Cost: Within +/-10% of planned cost

Technical: Meeting or exceeding exit criteria

The TRL levels will be tracked by the Project Manager on a quarterly basis to ensure ASMM product maturity is obtained based on the projected implementation schedule maintained by the AvSP Program Assessment Team. Impact assessments on accident categories will be performed by the AvSP Program Assessment Team on a periodic basis.

4.4 IMPLEMENTATION STRATEGY

Figure 4.4 reflects the implementation strategy of all of the capabilities developed under ASMM leading to the overall ASMM goal to support proactive management of Aviation Safety.

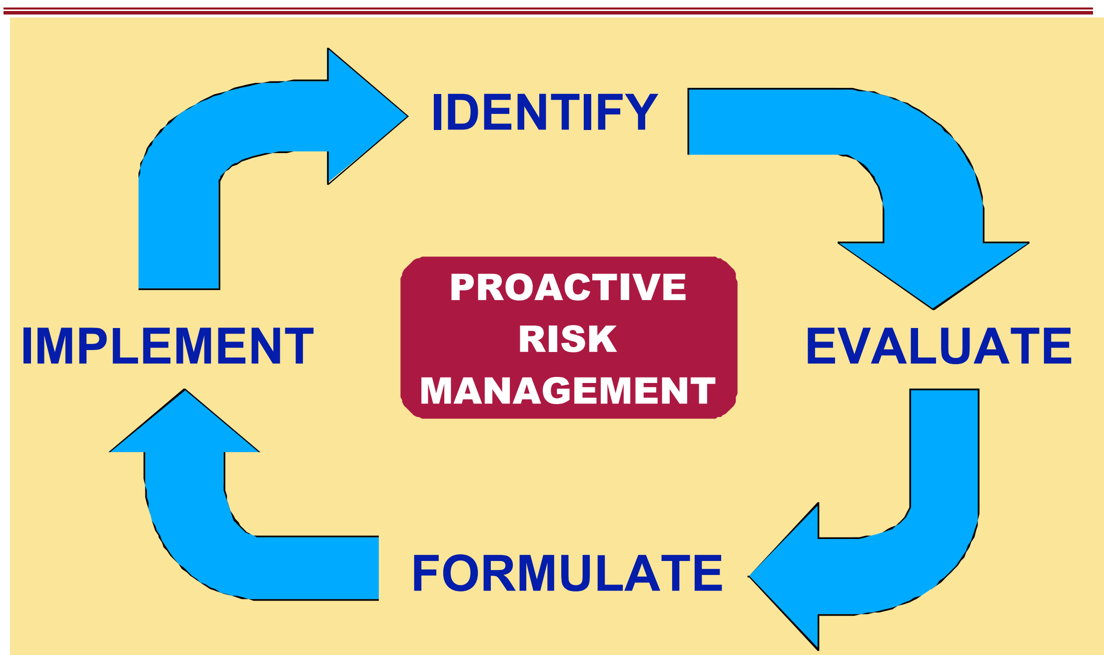


FIGURE 4.4
ASMM IMPLEMENTATION STRATEGY

Proactive Risk Management is implemented in an iterative loop of:

1. Identify
2. Evaluate
3. Formulate
4. Implement (and then continuous, iterative refinements of steps 1-4).

The relationship of the activities and developments under the ASMM sub-project to this concept of the cycle of proactive management of safety risk of Figure 4.4 is conveyed in Figure 4.5.

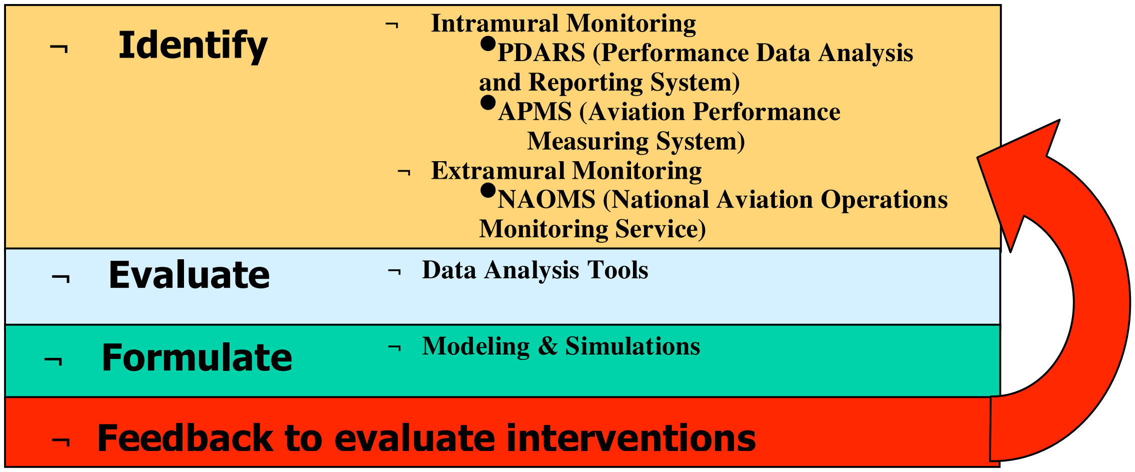


FIGURE 4.5
ASMM AND THE CYCLE OF PROACTIVE MANAGEMENT OF RISK

Identification is the process of continuously monitoring and comparing to expectations to uncover potential risks and to recognize improvements. This accomplished in a parallel bottom-up and top-down approach:

Intramural monitoring:

- FOQA/APMS – air carriers, ALPA, FAA, NASA, Teledyne Controls, Austin Digital, SFIM Inc., SimAuthor, etc.
- ASAP – air carriers, FAA, APA, ALPA
- PDARS – FAA, NASA, NATCA

Extramural monitoring:

ASRS – FAA, NASA, the US aviation community
SAPS – FAA
NASDAC – FAA
GAIN – FAA, the international aviation community
SPAS – FAA
NAOMS - NASA

Evaluation involves the diagnosis of causal conditions, the quantification of frequency, and the assessment of severity. The following data analysis tools will be used to meet the evaluation requirements:

- Automated data quality checking and filtering
- Database storage & middleware technologies
- Automated pattern-search tools
- Automated extraction of information from textual reports
- Automated linkage of relevant information from heterogeneous data sources
- Automated advisors of significant factors in numeric & textual data

Developments in these areas will require significant coordination, validation, and calibration efforts among all participating research organizations, government agencies, international and industry efforts.

Formulation is the consideration of changes, the assessment of safety risk, and the estimation of benefits and costs of intervention. This process is fundamentally the responsibility of the Industry and the FAA and entails more than just the safety-risk assessment that is the focus of ASMM. However, formulation of an intervention will rely on the following tools:

- Information visualization tools - FAA, NASA, International & Industry Community
- Fast-time simulations to evaluate safety intervention strategies – NASA & FAA

Implementation is also the responsibility of the Industry and the FAA with the ASMM tools playing only a supportive role in the decision-making process. It is accomplished via prototypes, their effectiveness is evaluated, refinements are implemented, and then full-scale deployments are facilitated.

The implementation of the ASMM tools per se to support the decision makers throughout this cycle of proactive management is addressed throughout the process of their development. Requirements for data analysis tools start from the results of a User-needs Study conducted with each potential user in each operational environment (i.e., air carriers or ATC). The prototypes of the required capabilities for data analyses are developed under *Data Analysis Tools Development*. Collaboration is established with the potential user under a Space Act Agreement (SAA) to test and evaluate the prototypes in the operational environment under *Intramural Monitoring*. This initiates an iterative process during which the user becomes sufficiently familiar with the capability to suggest revisions or enhancements. This evolutionary process results in the customized product to meet the individual user's needs. In the case of an air carrier, the user may already have an on-going exceedance-based FOQA program in which case the flight-recorded data are being downloaded and processed by a commercial vendor of that capability. We enter into a separate SAA with that vendor so that, if and when the air carrier and the vendor agree that the capability should be commercialized, we work with that vendor to transfer the technology. In the case of ATC data analysis tools, the primary user is the FAA and the PDARS program is already being carried out in collaboration with the FAA Office of System Capacity Requirements and the FAA Office of System Safety. From FY'00 through the present, PDARS is being tested and evaluated in the facilities of the ATC Western-Pacific Region. During FY'02, the PDARS network was extended to include the facilities of the Southwest Region. During FY'03, PDARS was extended to the facilities of the Southern ATC Region. In FY'03, the FAA announced the schedule for extending the test and evaluation of PDARS to all 20 ATC Centers in the continental U.S. before the end of FY'04. Once the prototypes have completed these developmental phases, we may consider that the technologies have been effectively transferred and the overall plan for their future evolution and application is primarily an Industry-FAA task.

ASMM is also a significant part of the "Aviation Safety Risk Analysis" research area of the FAA/NASA Aviation Safety Research Joint Working Group. Joint roadmaps of FAA and NASA activities in this research area have been submitted for approval by the Co-Chairs of the Working Group. ASMM products have been identified as supporting 15 initiatives in the FAA's Flight Plan 2004-2008.

5.0 AGREEMENTS

NASA does not have sufficient funds to address all the monitoring, data analysis and data sharing issues identified by industry customers. To complete the research picture the ASMM team coordinates with other projects so that the research is complementary and addresses the highest priority issues. The Program manager reviews other's research projects on a continuing basis. It is critical to partner with other research organizations in order to leverage our separate monitoring and data analysis efforts. Sharing of results, methods and metrics can enhance all research in these areas. Since research is often intrusive to operations, coordination of research logistics can be useful in minimizing disruption to customer operations.

5.1 NASA

5.1.1 Other AvSP Projects

ASMM entails capabilities that cut across several of the other AvSP Projects. ASMM is coordinating with the Single Aircraft Accident Prevent (SAAP) project on engine health monitoring. The APMS tool for extracting atypical flights can be adapted to monitoring engine operations for on-condition maintenance. The ASMM Modeling and Simulation tools may well be used to evaluate potential issues of human factors associated with some of the products being developed under the other projects. Additional work is being defined for coordination of data handling, middleware, and standards for operational data usage and analysis for the Weather and Synthetic Vision projects. APMS has focused on major air carriers due to limitations of funding. However, there is a clear recognition of the need to adapt these capabilities to the special requirements of the GA and the Rotorcraft communities.

5.1.2 Other NASA Programs

The ASMM sub-project is also coordinating closely with the Advanced Air Transportation Technology (AATT) Project and with the Engineering for Complex Systems (ECS) Program in several areas: modeling, fast-time simulation, air traffic control monitoring and analysis, and metrics and measurements of safety, as well as data management/access issues.

5.2 NON-NASA

The plan for ASMM developments is compatible with, and complementary to on-going activities in the US and Europe such as the FAA-Industry FOQA program, the UK CAA OFDM program, the ICAO initiatives, GAIN, Eurocontrol Performance Review Commission, ATAQ/ALPA/APA/NATCA positions and initiatives, etc., as well as NASA's current tools such as ASRS. The implementation approach will help improve current research activities for APMS, PDARS, NAOMS and various other data analysis tools as well as commercial and industry tools such as BASIS and OASIS. This will be accomplished through regular workshops to share technical issues, implementation results, and ongoing research and development strategies.

5.3 PARTNERS

Data Analysis Tools Development, Intramural Monitoring, and Extramural Monitoring:

- Flight Safety Foundation Icarus Committee's Working Group on Flight Operations Risk Assessment System
- ICASS (International Confidential Aviation Safety Systems) committee
- Active participation of IATA and ICAO in the taxonomy workshop
- Member of the Global Aviation Information Network (GAIN) Working Group B
- Commercial Aviation Safety Team (CAST)
- Alaska Airlines

- American Airlines
- Delta Airlines
- Teledyne Controls
- SFIM, Inc.
- SimAuthor Corp

Modeling & Simulation:

- FAA Tech Center
- FAA Office of System Capacity Requirements
- FAA Office of System Safety
- Air Force (human behavioral modeling)
- International Organizations: Eurocontrol, Civil Aviation Authority (CAA), Office National d'Études et de Recherches Aérospatiales (the French National Aerospace Research Establishment) (ONERA), National Aerospace Laboratory NLR (Netherlands) and German Aerospace Center (DLR)

6.0 RESOURCES

FUNDING REQUIREMENT

6.1.1 Resources Funding Chart by Project/Element/Center

TABLE 6.1

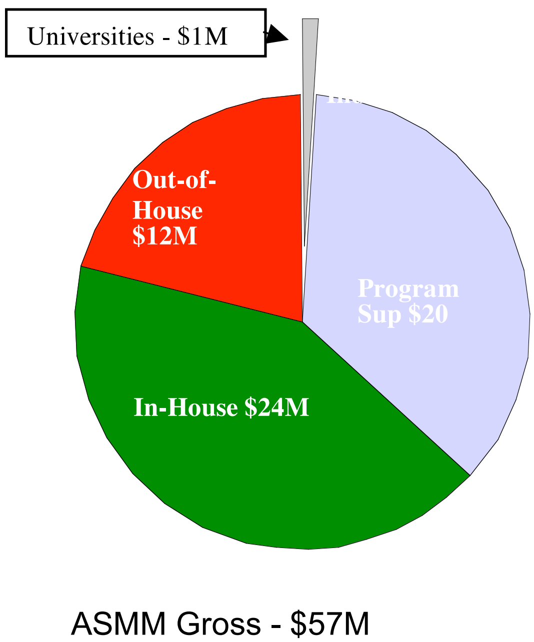
ASMM SUB-PROJECT FUNDING BREAKDOWN (728-10)

		FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	Total
2.1.1 Data Analysis and Intramural Monitoring	-10	3.061	3.422	1.593	0.995	1.100	0.450	10.171
	ARC	2.633	3.000	1.508	0.995	1.100	0.450	9.686
	GRC	0.305	0.321	0.085	0.000	0.000	0.000	0.711
	LaRC	0.123	0.101	0.000	0.000	0.000	0.000	0.224
2.1.2 Extramural Monitoring	-20	0.975	1.600	1.739	1.852	1.997	0.900	9.063
	ARC	0.975	1.600	1.739	1.852	1.997	0.900	9.063
2.1.3 Modeling and Simulations	-30	0.758	0.872	1.108	1.376	1.431	0.500	6.045
	ARC	0.586	0.645	0.825	0.904	0.959	0.500	4.419
	GRC	0.172	0.227	0.283	0.472	0.472	0.000	1.626
2.1.4 Information Sharing	-40	1.732	0.370	0.000	0.000	0.000	0.000	2.102
	ARC	0.960	0.370	0.000	0.000	0.000	0.000	1.330
	DFRC	0.772	0.000	0.000	0.000	0.000	0.000	0.772
2.1.5 Intramural Monitoring	-50			2.750	2.657	2.538	1.026	8.971
	ARC			2.750	2.657	2.538	1.026	8.971
2.1.X Research Support	XX	0.000	0.000	0.000	0.000	0.000	4.000	4.000
	ARC	0.000	0.000	0.000	0.000	0.000	4.000	4.000
Net Totals		6.526	6.264	7.190	6.880	7.066	6.876	40.802
	ARC	5.154	5.615	6.822	6.408	6.594	6.876	37.469
	DFRC	0.772	0.000	0.000	0.000	0.000	0.000	0.772
	GRC	0.477	0.548	0.368	0.472	0.472	0.000	2.337
	LaRC	0.123	0.101	0.000	0.000	0.000	0.000	0.224
Service Activities		2.125	2.947	2.430	4.207	4.326	4.424	20.459
	ARC	1.718	1.931	2.146	4.124	4.243	4.424	18.586
	DFRC	0.140	0.160	0.000	0.000	0.000	0.000	0.300
	GRC	0.159	0.197	0.217	0.083	0.083	0.000	0.739
	LaRC	0.108	0.659	0.067	0.000	0.000	0.000	0.834
Gross Totals		8.651	9.211	9.620	11.087	11.392	11.300	61.261
	ARC	6.872	7.546	8.968	10.532	10.837	11.300	56.055
	DFRC	0.912	0.160	0.000	0.000	0.000	0.000	1.072
	GRC	0.636	0.745	0.585	0.555	0.555	0.000	3.076
	LaRC	0.231	0.760	0.067	0.000	0.000	0.000	1.058

Note: Funding available for procurement in FY'05 had not been defined as of the date of this version of the Project Plan pending resolution of full cost accounting. The milestones and deliverables scheduled for FY'05 are based on current expectations.

6.1.2 Acquisition Strategy Plan

ASMM/Resource Estimates Assumptions



Assumptions

- Strong Industry Participation in Data Access
  - Providing key controlled access to sensitive data
- No new major facilities required
- Resource Planning based on existing programs, e.g.:
  - APMS & ASRS
  - AATT Programs: CTAS, SMA, AvSTAR
  - DARWIN, NPSS, ECS
- FAA Collaboration
  - Coordinating with Tech Center, Safety & Capacity Offices, and Human Factors Research
  - ASMM intramural development approach
  - minimized funding issues with the FAA
  - jointly developed roadmaps

FIGURE 6.1.2
ASMM SUB-PROJECT RESOURCES

The ASMM sub-project is using a variety of procurement vehicles to address acquisition requirements. These vehicles include:

- NASA Research Agreements (NRA's)
- In-House Contractors
- Memorandum of Understanding (MOU)/Memorandum of Agreement (MOA) with other agencies and research organizations
- University Grants

The vast majority of ASMM procurements are software development oriented in nature. Most hardware components are on the GSA schedule. Very few items require sole source justification and there is no significant customized hardware development. GRC and DFRC used existing contracts and procurement vehicles on related programs to simplify development and procurement of unique hardware and software during their participation in the ASMM Sub-Project.

6.2 WORKFORCE

6.2.1 Workforce Chart by element/center

TABLE 6.2.1(A)

ASMM 728-10 CIVIL SERVANTS WORKFORCE (DIRECT) (FTE)

		FY 00	FY 01	FY 02	FY 03	FY 04	FY 05
2.1.1 Data Analysis Tools Development	-10	2.6	4.7	2.0	2.0	2.0	1.0
	ARC	1.6	3.7	2.0	2.0	2.0	1.0
	GRC	0.5	0.5	0.0	0.0	0.0	0.0
	LaRC	0.5	0.5	0.0	0.0	0.0	0.0
2.1.2 Extramural Monitoring	-20	1.5	2.5	2.5	2.5	2.5	1.5
	ARC	1.5	2.5	2.5	2.5	2.5	1.5
2.1.3 Modeling and Simulation	-30	0.7	1.3	1.1	1.1	1.1	1.0
	ARC	0.7	0.8	1.1	1.1	1.1	1.0
	GRC	0.5	0.5	0.0	0.0	0.0	0.0
2.1.4 Information Sharing	-40	3.1	4.6	0.0	0.0	0.0	0.0
	ARC	1.5	4.6	0.0	0.0	0.0	0.0
	DFRC	1.6	0.0	0.0	0.0	0.0	0.0
2.1.5 Intramural Monitoring	-50			3.0	3.0	3.0	1.5
	ARC			3.0	3.0	3.0	1.5
TOTAL		8.4	13.1	8.6	8.6	8.6	5.0
	ARC	5.3	11.6	8.6	8.6	8.6	5.0
	DFRC	1.6	0.0	0.0	0.0	0.0	0.0
	GRC	1.0	1.0	0.0	0.0	0.0	0.0
	LaRC	0.5	0.5	0.0	0.0	0.0	0.0

TABLE 6.2.1(B)

ASMM 728-10 PERFORMANCE BASED CONTRACTORS (PBCs)

		FY 00	FY 01	FY 02	FY 03	FY 04	FY05
2.1.1 Data Analysis and Intramural Monitoring	-10	15.5	17.5	12	8.5	8.5	4.0
	ARC	7.0	10.0	5.0	5.0	5.0	2.5
	Rannoch	2.0	2.0	2.0	1.5	1.5	0.0
	Sandia	2.0	2.0	2.0	1.5	1.5	1.5
	FSF	1.5	1.5	0.0	0.0	0.0	0.0
	Naval Research Lab	0.5	0.5	1.0	0.5	0.5	0.0
	VPI	1.0	0.0	0.0	0.0	0.0	0.0
	Univ of Alabama	1.0	0.0	0.0	0.0	0.0	0.0
	Ultimode	1.0	0.0	0.0	0.0	0.0	0.0
	Oregon Graduate Institute	0.0	1.0	1.0	0.0	0.0	0.0
	SUNY Stoneybrook	0.0	1.0	1.0	0.0	0.0	0.0
2.1.2 Extramural Monitoring	-20	5.0	9.0	9.0	9.0	9.0	6.0
	ARC	5.0	9.0	9.0	9.0	9.0	6.0
2.1.3 Modeling &Simulations	-30	6.0	6.0	6.5	6.0	5.0	6.0
	ARC	1.5	1.5	1.5	1.0	1.0	1.5.
	SJSU	1.0	1.0	1.5	1.5	1.5	1.5
	ATAC	1.5	1.5	1.5	1.5	1.5	2.0
	GA TECH	1.0	1.0	1.0	1.0	1.0	1.0
	NLR	1.0	1.0	1.0	1.0	0.0	0.0
2.1.4 Information Sharing	-40	5.2	5.2	0.0	0.0	0.0	0.0
	ARC	5.2	5.2	0.0	0.0	0.0	0.0
2.1.5 Intramural Monitoring	-50	0.0	0.0	9.0	8.0	8.0	6.0
	ARC	0.0	0.0	9.0	8.0	8.0	6.0
TOTAL PBCs		30.7	36.7	36.5	31.5	30.5	22.0
	ARC	18.7	25.7	24.5	23.0	23.0	16.0
	Rannoch	2.0	2.0	2.0	1.5	1.5	0.0
	Sandia	2.0	2.0	2.0	1.5	1.5	1.5
	FSF	1.5	1.5	0.0	0.0	0.0	0.0
	Naval Research Lab	0.5	1.0	1.0	0.5	0.5	0.0
	VPI	1.0	0.0	0.0	0.0	0.0	0.0
	Univ of Alabama	1.0	0.0	0.0	0.0	0.0	0.0
	Ultimode	1.0	0.0	0.0	0.0	0.0	0.0
	Oregon Graduate Institute	0.0	1.0	1.0	0.0	0.0	0.0
	SUNY Stoneybrook	0.0	1.0	1.0	0.0	0.0	0.0
	SJSU	1.0	1.0	1.5	1.5	1.5	1.5
	ATAC	1.5	1.5	1.5	1.5	1.5	2.0
	GA TECH	1.0	1.0	1.0	1.0	1.0	1.0
	NLR	1.0	1.0	1.0	1.0	0.0	0.0

6.3 FACILITIES USAGE CHARTS

6.3.1 Graphic

TABLE 6.3.1
ASMM FACILITY REQUIREMENTS (utilization duration TBD)

FACILITY	CTR	SCV ACT.	FY 00				FY01				FY02				FY03				FY04				FY05			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Future Flight Central (FFC)	ARC	TBD																								
Numeric Aerodynamic Simulator	ARC	TBD																								
CVSRF	ARC	TBD																								

100%	41-60%
81-99%	21-40%
61-80%	0-20%

TBD - data were unavailable

Note: Although their use may have been contemplated at the start of the project, ASMM now foresees no requirement for utilization of these or any other facility.

6.3.2 Test and Verification of Technology

Each ASMM element may have particular needs for test and verification. In some cases, hardware, software, or integration system testing, or some combination, is an output or significant component of the ASMM element. Test and verification plans will be developed and referenced in the ASMM sub-project or element plans. Most of the products of ASMM rely on collaborations with the user communities to test and evaluate them in the operational environment. In those cases, established processes will be applied to the components under development. In the few situations in which the indicated facilities may be used, these processes will be monitored by the Office of Safety, Environment, and Mission Assurance at NASA/ARC.

7.0 TECHNOLOGY TRANSFER/COMMERCIALIZATION

The ASMM sub-project emphasizes rapid and effective dissemination of the technology to the U.S. industry. The primary ASMM strategy for technology transfer is to involve partners as participants in the development of the new technologies. Requirements for data analysis tools start from the results of a User-needs Study conducted with each potential user in each operational environment (i.e., air carriers or ATC). Collaboration is established with the potential user under a Space Act Agreement (SAA) to test and evaluate the prototypes in the operational environment. This initiates an iterative process during which the user becomes sufficiently familiar with the capability to suggest revisions or enhancements. This evolutionary process results in the customized product to meet the individual user's needs. In the case of an air carrier, the user may already have an on-going exceedance-based FOQA program in which case the flight-recorded data are being downloaded and processed by a commercial vendor of that capability. We enter into a SAA with that vendor so that when the air carrier and the vendor agree that the capability should be commercialized we work with that vendor to transfer the technology. In the case of ATC data, the primary user will be the FAA and the PDARS program is already being carried out in collaboration with the FAA Office of System Capacity. PDARS is being evaluated in the FAA's air traffic control facilities. Once the prototypes have completed these developmental phases, we consider that the technologies have been effectively transferred and the plan for their future use and evolution is primarily an Industry-FAA task.

NASA inventions have been and will be disclosed as such and patents or copyrights applied for as appropriate. Non-exclusive licensing agreements will be pursued with current vendors of similar software. APMS tools, for example, are likely to be of interest to the vendors of software in support of current FOQA exceedances-based programs. Milestones in FY'04-'05 are to identify such vendors and transfer the technologies under licensing agreements.

Some technology exists in Department of Defense (DOD) applications; the feasibility of incorporation of similar technology into the civil fleet will be evaluated with the civil partners. In addition, transfer of technology, such as PDARS, is being coordinated with related FAA research activities and will be further facilitated by testing in FAA facilities under representative operational conditions. Finally, development of new technology and data will be distributed to industry via reports, society conferences, and workshops.

8.0 PRODUCT ASSURANCE

A plan has been established by the project manager for proactive decision making to continually identify, analyze, plan, track, control, and communicate risk within the elements. This plan will follow the guidelines of NASA Programs and Project Management Processes and Requirements document, NPG 7120.5A. The plan will utilize the AvSP common process, methods and tools, in order to establish a disciplined approach. The Offices of Safety & Assurance Technology (OSAT) trained personnel from ASMM sub-project in the Continuous Risk Management process during FY2000 and FY2001.

8.1 DE-SCOPE METHODOLOGY

Project Level Strategies

Phase I - Extend or de-scope ASMM sub-project milestones
Phase II - Reduce the number of target users for given element implementation

Element Level Strategies
Phase III - Reduce the scope of the Information Sharing Element
Phase IV - Reduce the scope and duration of NAOMS development and deployment
Phase V - Reduce the scope and duration of APMS development and deployment
Phase VI - Reduce the scope of the Modeling and Simulation Element
Phase VII - Reduce the scope and duration of PDARS development and deployment
Phase VIII - Discontinue the Modeling & Simulation Element
Phase IX - Discontinue ASMM project

8.2 RISK MITIGATION

Risk Management is a structured, continuous process for proactive AvSP decision making to identify program risks (i.e., what could go wrong), prioritize these risks to determine which need to address, and implement strategies to deal with unacceptable risks. For the AvSP, risk management and control requirements are tailored to each Project. Each Center S&MA Office will be an active participant with the projects and provide risk management guidance.

The primary risk categories for AvSP are: (1) technical—critical enabling technologies encountering unexpected developmental difficulties, (2) physical risk to personnel and property, and (3) programmatic—resources unavailable because of competing technology development priorities. The AvSP has been planned with no program reserve, which increases the technical and programmatic risks to each of the elements. Each Element Manager will identify and prioritize risks and document them in the applicable element plans. Several potential risks and mitigation strategies have been identified for the ASMM sub-project (see Table 8.2). These risks will be incorporated into the element risk identification process.

Product and Hazard	Probability of Occurrence	Consequences of Occurrence	Mitigation Strategy and Action	Implementation Probability
AVIATION PERFORMANCE MEASURING SYSTEM (APMS): APMS is an integrated suite of tools to facilitate implementation of routine flight-data analyses within each air-service provider. APMS develops and documents the software and procedures for data management and analyses of flight-recorded data that enable users to interpret implications in safety and efficiency of flight				**Very High:** Some APMS tools are already in daily use. Partners have shown interest in implementing most APMS advanced tools. Vendors commercialized two APMS products and are interested in others.
FAA has made it mandatory that air carriers with FOQA programs submit summary FOQA data to the FAA. Air carriers are cautiously continuing FOQA programs while negotiating the requirement. They fear that these data may be misused by FAA or by media or by lawyers (if accessed under FOIA by subpoena). Pilots, unions, and airlines are concerned the FAA may use these data to investigate individual pilots or airlines for violations of FARs.	**HIGH:** FAA has issued its FOQA rule that makes it mandatory for air carriers with FAA-approved FOQA programs to provide aggregate data	It has been difficult for APMS to gain access to flight-recorded data even though it currently operates with de-identified data behind each air carrier's firewalls.	Continue to show air carriers the feasibility and value of routinely monitoring and analyzing de-identified flight data to aid in proactive management of safety risk. FAA's new FOQA rule provides protection for individual airmen. FAA sponsors meetings among FOQA air carriers to encourage exchange of information..	
NASA may not be able to access and merge the information obtained by multiple air carriers from routinely analyzing flight data because of concerns for FOIA subpoena and possible misuse of the information.	**MEDIUM:** Air carriers are expressing concern since the issuance of the FAA rule on FOQA data.	ASMM could not achieve its primary objective of enabling proactive system-wide safety risk management.	Demonstrate the value of system-wide monitoring. Continue to build trust with airlines and unions in NASA as an "objective broker" of data.	
NASA may be limited in the size of the databases to which it is given access either because of the limitations of fleet type, size and operations of current collaborating air carriers or because of constraints on merging data from multiple air carriers.	**LOW:** Alaska, American, and Delta Airlines have provided access to adequate databases.	We could not demonstrate ability to extend database-mining tools to large databases.	Continue to work tactfully with the several air carriers who seem somewhat receptive to merging their de-identified databases.	

TABLE 8.2 (CONTINUED)
TECHNOLOGY/IMPLEMENTATION RISKS AND MITIGATION STRATEGIES

Product and Hazard	Probability of Occurrence	Consequences of Occurrence	Mitigation Strategy and Action	Implementation Probability
PERFORMANCE DATA ANALYSIS AND REPORTING SYSTEM (PDARS): Provides the capability to: collect and process ATC operational data; compute quantitative operational performance measures on a regular basis relating to established FAA metrics; conduct operational problem identification and causal analyses; access simulation tools for analyses of system improvement options; achieve performance statistics and basic operational data for use in research development and planning studies				**Very High:** PDARS is being used daily by facilities in Western-Pacific, South & Southwest Regions. Feedback is unanimously enthusiastic. FAA has announced a schedule for installing PDARS in the remaining ATC Centers.
FAA may choose to use information developed by PDARS to discipline controllers. If this occurs, the National Air Traffic Controllers Association (NATCA) will take action to prevent any further routine analyses of ATC data.	**LOW:** FAA has said that this would not happen. NATCA has signed an agreement to cooperate.	PDARS would not be able to access data needed to perform meaningful nationwide analysis	With our assistance, FAA and NATCA have executed a formal agreement that PDARS is to be used in a non-punitive environment and a culture of trust essential to safety.	
FAA may choose to deploy PDARS nationally. Current ASMM resources are only sufficient to implement and maintain the PDARS evaluation in the Western-Pacific Southwest, and South ATC Regions.	**HIGH:** FAA has made de facto decision to extend PDARS.	FAA will be responsible for deployment after FY'05	Seek funding from FAA to lead the User-needs Studies in other ATC regions as needed.	
Some radar track data have errors or dropouts.	**HIGH**	Bad data will skew results	Develop data-analysis algorithms to identify & eliminate bad data	
The data to be processed, managed, and stored from the entire national ATC system may overwhelm current PDARS capabilities for daily reporting.	**MEDIUM**	PDARS would not be ready for nationalization.	Encourage FAA to provide the funding needed to design a PDARS to cope with VERY large volumes of data of a national system.	
FAA's focus for PDARS is primarily on capacity and this may conflict with the focus of NASA's Aviation Safety Program on safety.	**LOW:** Not very probable with the current FAA participants	FAA and NASA may diverge on the objectives of PDARS.	Continue to work closely with both the Office of System Capacity and the Office of System Safety in the FAA to ensure that both aspects are appropriately addressed in PDARS.	

TABLE 8.2 (CONTINUED)
TECHNOLOGY/IMPLEMENTATION RISKS AND MITIGATION STRATEGIES

Product and Hazard	Probability of Occurrence	Consequences of Occurrence	Mitigation Strategy and Action	Implementation Probability
NAS OPERATIONS MONITORING SERVICE (NAOMS): Aims at developing methodologies for a permanent field implementation of NAOMS responsible for maintaining a comprehensive and coherent survey of the safety and performance of the NAS from the perspective of front line personnel NAS-wide. It is a proactive companion to the ad hoc submittal process embodied within ASRS				**High:** There is no other viable way to address the targeted problem. The reaction of the community to the initial phase of the survey has been very positive. There is no reason to expect that the other constituencies will be any less responsive when they are approached.
Both questioners and interviewees in NAOMS survey process have internal biases.	**HIGH**	Biases may skew survey results	Subjectivity is inherent in surveys, but can be taken into account by developed scientific procedures	
Interviewees in the NAOMS process are self-selected.	**HIGH**	May skew analysis results towards those most likely to report problems.	This to can be accounted for with correct and proven scientific procedures.	
Outside parties may press to gain access to NAOMS survey data prematurely.	**HIGH**	Results are misinterpreted thereby damaging integrity of survey process	Limit access to the NAOMS survey to the NAOMS Team of experts until the process has matured.	
Outside parties may press to gain access to NAOMS survey data and use them in their own analyses	**MEDIUM**	NAOMS results are used in questionable fashion to support parochial interests of users thereby damaging integrity of the process	Limit access to the NAOMS survey process to the NAOMS Team of experts until the process has matured.	

TABLE 8.2 (CONTINUED)
TECHNOLOGY/IMPLEMENTATION RISKS AND MITIGATION STRATEGIES

Product and Hazard	Probability of Occurrence	Consequences of Occurrence	Mitigation Strategy and Action	Implementation Probability
SYSTEM-WIDE INCIDENT REPORTING ENHANCEMENTS: Upgrade of the 24-year old technology of the ASRS database to include: conversion of ASRS legacy database to ORACLE; electronic submission of reports; and test and evaluation an analyst decision-support system				**Very High:** Some of the improvements are already in daily use by the ASRS Office and it is expected that all will be implemented eventually. It is very likely that most, if not all, of these will find application in similar databases like ASAP and NAOMS
Insufficient funds to adapt new technological capabilities developed by other elements of ASMM to routine processing of incident reports.	**HIGH.**	Safety personnel would not be able to utilize to the fullest data sources that are essential to causal analyses and proactive management of risk.	Continue to seek funding from other sources that could equally benefit from efficient and reliable automated processing of anecdotal reports.	
Electronic submission of reports may be perceived as having inadequate security.	**MEDIUM**	Sources will be unwilling to provide data.	Continue to work with air-services providers to ensure that acceptable procedures are built into system.	

TABLE 8.2 (CONTINUED)
TECHNOLOGY/IMPLEMENTATION RISKS AND MITIGATION STRATEGIES

Product and Hazard	Probability of Occurrence	Consequences of Occurrence	Mitigation Strategy and Action	Implementation Probability
FAST-TIME SIMULATION OF SYSTEM-WIDE RISKS: Rigorously validated models and simulations of relationship among elements of the NAS to support predictions and safety-risk assessments of system-wide effects of new flight and ATC technologies and/or procedures before they are inserted into the operating environment. Includes engineering models, operating concept models, support/logistics models, human performance models and risk analyses				**Medium to Low:** This is the only viable approach to addressing the targeted problem in an objective manner, but it will likely always require specialized expertise from government or academia to utilize the capability correctly and effectively
Air carriers, unions, and regulatory agencies typically do not have the required expertise to make correct and adequate use of models and simulations, particularly when they contain representations of human behavior and performance.	**HIGH**	Airlines may use models and simulation tools incorrectly or not consider their predictions at all.	Use NASA experts as "custodians" of simulation tools, in advisory role to users.	
The current tasks to develop modeling and simulations including human behavior utilize a large and diverse team of contractors. Not all may achieve equal standards of performance.	**MEDIUM**	If one subcontractor does not perform, project objectives may not be met	Maintain strong and knowledgeable management with well structured and defined program and schedule of sub-tasks to which all responsible participants agree.	
Expertise in human behavior modeling is limited to very few experts worldwide. European researchers, in particular, have made notable contributions to modeling human behavior. NASA's ability to exploit this knowledge is limited because of current constraints against funding European research.	**HIGH**	Project will not achieve results that could have been possible with European input	Devise some funding mechanism by which NASA can include European expertise on modeling team.	
The TRL of Modeling and Simulations will not achieve the levels attained by the products of Intramural and Extramural Monitoring.	**HIGH**	Modeling and simulation technologies will require continued government investment in their effective utilization and development.	Work to establish an effective service to the industry within NASA.	

TABLE 8.2 (CONTINUED)
TECHNOLOGY/IMPLEMENTATION RISKS AND MITIGATION STRATEGIES

Product and Hazard	Probability of Occurrence	Consequences of Occurrence	Mitigation Strategy and Action	Implementation Probability
PROTOTYPE SYSTEM-WIDE RISK ASSESSMENT CAPABILITY: A capability that demonstrates the feasibility and value of automatically merging de-identified disparate data sources to assess system-wide safety risks				**Medium to High:** The technology for merging databases and extracting useful information exits, but there remains a "political" issues of getting agreements from the air carriers, the unions, and the ATC to provide access to the data to demonstrate the value (contingent on the availability of FY 05 funding)
There is no provision in the current ASMM sub-project Plan for merging all of the heterogeneous data and information acquired by tools such as APMS from flight data and PDARS from ATC data and NAOMS from survey data and Simulations and other diverse sources. The proposed enhancements and augmentations to enable such information to be merged and analyzed routinely may not be funded.	**HIGH**	ASMM would fail to achieve its primary objective of providing the industry with regular, reliable, insightful, and immediately useful information to aid in assessing the performance and safety of the nationwide NAS.	Augment the ASMM sub-project for FY'05-FY'09 as proposed.	
Key data sources (airlines and FAA ATC) do not trust each other and may not agree to merge their data.	**HIGH**	Inability to merge airline and FAA ATC operational data will limit causal analysis and risk assessment.	Work tactfully with all sides to develop adequate trust and acceptable "quid pro quo" to participate in a demonstration of the benefits to all of merging flight and ATC data.	

TABLE 8.2 (CONTINUED)
TECHNOLOGY/IMPLEMENTATION RISKS AND MITIGATION STRATEGIES

Implementation of various ASMM systems as separate entities will provide tools to handle data, but integrating their products is the real objective of the program to enable national analysis of precursors and causal data. Not enough emphasis has been put on integration.	**HIGH**	Data in separate systems cannot be viewed for a national perspective	Begin process of investigating how ASMM tools could be integrated to support safety-risk assessment from a national perspective.	
Supportability of ASMM systems for the system-wide perspective may become a cost issue as they grow in size and if NASA takes over the role as national data repository	**HIGH**	Not enough resources to support full system implementation and integration for the nationwide perspective.	Turn over system support to private entities that can put ASMM data to commercial use, or transfer support functions to contributing airlines, or seek a Congressional line item for NASA's custodianship of a national resource.	

9.0 REVIEWS

Various reviews have been established to communicate the aviation safety information to AvSP management and committees.

9.1 MONTHLY

Monthly Report by the Project Managers to the AvSP Manager has been developed:

- This report is an integrated technical, cost, and schedule assessment of progress versus plans and will contain significant technical highlights. The monthly report will be prepared in a standard, consistent electronic format, including appropriate graphics and accompanying explanatory text.
- A narrative description will also be developed to identify any problems, issues, and concerns (along with potential impact and proposed action) and any major interactions with industry

9.2 INDEPENDENT REVIEWS

The Sub-Project will participate as appropriate in reviews with significant industry and other Government agency partner participation, including the FAA. Collaboration among partners is encouraged at the reviews. Each participant will present his/her accomplishments and plans, and significant technology developments will be demonstrated. As required, the Sub-Project Manager will present technical status overviews at Agency-sponsored Independent Implementation Reviews that are intended to assess Project stability; and participate in independent Aviation Safety Program Executive Council meetings or Aviation Safety Working Group meetings that are intended to review technical progress, assess technology impact, and assess technology relevance. The Sub-Project Managers will also participate as required in technical quality reviews, such as those conducted by the National Research Council.

9.3 AD HOC REVIEWS

During FY'01, two reviews were conducted of the Aviation Performance Measuring System (APMS) project. The first was for the ASRS/APMS Advisory Subcommittee on November 14, 2000. This group was asked to

- Assess the state of the art and expected near-term developments of FOQA.
- Identify key technical challenges in analyzing and fully capitalizing on FOQA-like data.
- Review the progress of APMS to date.
- Evaluate our plans and expected products.
- Recommend direction and focus of future NASA work.

At the conclusion of the presentations and discussions, the members of this groups said that they

- Supported the proposed future plans,
- Generally recognized and approved past contributions,
- Could not address priorities,
- Encouraged us to help the GA and rotorcraft communities,
- Cautioned against pursuing developments beyond points of diminishing returns.

The second review was for the Aviation Safety Program's APMS Industry Review on February 26-27, 2001. This group was asked to To assess status of the FOQA industry

- Identify key challenges in 3-5 year timeframe
- Assess APMS contributions to current status
- Assess APMS current plans
- Recommend APMS changes to advance FOQA

The report of this review

- Credited APMS with moving FOQA forward in the US during mid to late ‘90’s.
- Commended partnering with operators and vendors for focusing on operational problems.
- Noted that COTS vendors have closed gap with APMS tools for exceedance-based FOQA.
- Recognized that the private sector is focused on existing products and give little thought to R&D for future needs.
- Found remarkable consensus among vendors, government and Board members on types of tools that should be addressed by APMS.

This group gave recognition to the past accomplishments of the APMS Research Team and directed it to focus on advanced functions in the future.

Ever since the initial implementation of the PDARS initial experiment in the ATC Western-Pacific Region in early FY’00, meetings of the users have been convened every 3 months to obtain feedback, provide recurrent training, and discuss future enhancements.

The NAOMS Team meets irregularly with groups representing the various constituencies of the aviation community to keep them informed of progress and plans for the survey.

During FY’03, a Panel of the National Research Council conducted a review of the Aviation Safety Program. The first step of this review entailed written responses to a set of questions. This was followed with formal presentations on all aspects of the ASMM sub-project to the entire Panel in February 2003. On May 7, 2003, a subset of the Panel traveled to ARC to conduct an on-site full-day review of the ASMM sub-project during which the members of the review team met and spoke with all of the key civil servant and contractor personnel. The results of this review were included in the NRC report “An Assessment of NASA’s Aeronautics Technology Programs” issued in November 2003.

9.4 OTHER PROJECT MEETINGS

TBS

10.0 TAILORING

Based on the descriptions, definitions, and requirements in NPG 7120.5a, the following tailoring has been applied to this plan:

- Customer Definition and Advocacy is discussed under Section 1.0, Introduction.
- Project Authority, Management and Control are discussed under Section 3.0, Project Authority/Management.
- Technical Summary, Schedules, Implementation Approach and Technical Assessments are discussed under Section 4.0, Technical Approach.

- Agreements and Program/Project Dependencies are discussed under section 5.0, Agreements.
- Resources and Acquisition Summary are discussed under Section 6.0, Resources.
- Commercialization is discussed under Section 7.0, Technology Transfer/Commercialization.

Performance Assurance, Environmental Impact and Safety are not considered applicable to the Aviation Safety Program.

11.0 ACCOMPLISHMENTS

Monthly status reports and accomplishments can be found at the following url location:

https://ace.arc.nasa.gov:443/postdoc/t/folder/main.ehtml?url_id=11237